IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

MIT'S COUNTER-STATEMENT OF FACTS
PURSUANT TO LOCAL RULE 56.1 IN
OPPOSITION TO HARMAN'S MOTION FOR SUMMARY
JUDGMENT OF UNENFORCEABILITY OF THE '685 PATENT

MIT's Statement of Facts

1. The Massachusetts Institute of Technology ("MIT") is the owner of U.S. Patent No. 5,177,685 ("the '685 patent") that was duly issued on January 5, 1993 from U.S. Patent Application No. 565,274, which was filed on August 9, 1990. Exh. 1.

2. The '685 patent is presumed valid. 35 U.S.C. § 282.

3. The '685 patent resulted from doctoral research conducted by James R. Davis and Christopher M. Schmandt at the MIT Media Laboratory ("Media Lab") titled the "Back Seat Driver."

Field Testing

4. The Back Seat Driver project lasted from about April 1988 through early 1991.

5. The Back Seat Driver was an automobile-based navigation system that provided spoken directions, like a "back seat driver."

6. During their research, a prototype system was used on test drives and field trials by Davis and Schmandt. Exh. 12 at 1101; Exh. 20 at 2-6; Exh. 21 at ¶ 118.

7. During the test drives or field trials, the driver-system interface was tested by a driver using a cellular telephone keypad to select a destination and then reacting to driving instructions provided by cellular telephone after the route was planned by a computer operating at the Media Lab. Exh. 18 at 6763; Exh. 19 at 6765; Exh. 21 at ¶¶ 118-119.

8. During the field trials, either Jim Davis or Chris Schmandt was in the car with the research prototype. Exh. 18 at 6763; Exh. 19 at 6765.

9. During the field trials, either Jim Davis or Chris Schmandt maintained control over who used the car with the research prototype as required by the MIT Committee on the Use of Humans as Experimental Subjects. Exh. 5 at ¶ 8; Exh. 18 at 6763; Exh. 19 at 6764-65.

10. Drivers of the Back Seat Driver research prototype were testing and reacting to the supplied spoken directions of the system, but they were not shown how the Back Seat Driver prototype worked. Exh. 5 at ¶ 9; Exh. 21 at ¶ 119; *see also* Exh. 11 at 169:4-11.

11. The vehicle with the Back Seat Driver prototype was stored in a private MIT garage that had card access. Exh. 24 at 160:22-161:2.

12. The subjects of the field trials did not receive compensation for their participation, nor were Jim Davis and Chris Schmandt conducting the field trials with a view to commercially exploiting the Back Seat Driver. Exh. 18 at 6763.

13. The drivers were subject to MIT's policy on human experimentation. Exh. 19 at 6764-65.

14. MIT did not withhold material information about the field trials and indeed, disclosed the field trials to the Patent Office at least five times. Exh. 1 at 3:4-8; Exh.12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938. MIT was not required to inform the Patent Office of any dates on which the subject matter of the '685 patent was reduced to practice under the rules of Patent Practice. Exh. 6 at ¶ 11; *see also* Manual of Patent Examining Procedure § 2138.05 ("Thus the inventor need not provide evidence of either conception or reduction to practice when relying on the content of the patent application").

15. An abstract titled "Synthetic Speech for Real Time Direction-Giving" was authored by Jim Davis and Chris Schmandt and was submitted to the Institute of Electrical and Electronics Engineers ("IEEE") in June 1989 ("the June 1989 abstract"). The June 1989 abstract disclosed the field trials. Exh. 12 at 1101.

16. The June 1989 abstract was cited and provided to the Patent Office in an Information Disclosure Statement filed on September 4, 1990, was considered by Examiner Pipala, and

appears on the face of and was incorporated by reference in the ’685 patent. Exh. 1 at cover page & 3:57-66; Exh. 2 at 336, 345; Exh. 12 at 1101-1102.

17. An article related to the June 1989 abstract titled “Synthetic Speech for Real Time Direction-Giving” was authored by Jim Davis and Chris Schmandt and was submitted to the IEEE in August 1989 and published September 8, 1989 (“the September IEEE paper”). The September IEEE paper disclosed the field trials. Exh. 13 at 933-937.

18. The September IEEE paper was cited and provided to the Patent Office in an Information Disclosure Statement filed on September 4, 1990, was considered by Examiner Pipala, and appears on the face of and was incorporated by reference in the ’685 patent. Exh. 1 at cover page, 3:57-62, & 3:67-4:2; Exh. 2 at 336, 345; Exh. 13 at 933-937.

19. An article titled “The Back Seat Driver: Real Time Spoken Driving Instructions” was authored by Jim Davis and Chris Schmandt and was submitted to Harman’s navigation expert Robert L. French, who was “Vice-Chairman” of the “Technical Program Committee” and in charge of selecting interesting papers for the first-ever Vehicle Navigation & Information Systems Conference, held in September 1989 in Toronto, Canada (“the VNIS ’89 paper”). The VNIS ’89 paper disclosed the field trials. Exh. 16 at 278710-719; Exh. 15 at 938-942.

20. The VNIS ’89 paper was cited and provided to the Patent Office in an Information Disclosure Statement filed on September 4, 1990, was considered by Examiner Pipala, and appears on the face of and was incorporated by reference in the ’685 patent. Exh. 1 at cover page, 3:57-62, & 4:3-7; Exh. 2 at 336, 345; Exh. 15 at 938-942.

21. Jim Davis’ thesis, titled “Back Seat Driver: voice assisted automobile navigation system,” was submitted in the fall of 1989 and became publicly available in February 1990. The thesis disclosed the field trials. Exh. 14 at 457; *see also* Exh. 3 at 712-713; Exh. 17 at 1302.

22. Jim Davis' thesis was cited and provided to the Patent Office in an Information Disclosure Statement filed on September 4, 1990, was considered by Examiner Pipala, and appears on the face of and was incorporated by reference in the '685 patent. Exh. 1 at cover page, 3:57-62, & 4:8-10; Exh. 2 at 336, 346.

23. MIT's navigation expert, Dr. Elizabeth Cannon, provided an expert opinion on the materiality of the field trials. Exh. 21 at ¶¶ 118-120.

24. Harman has offered no opinion from any technical expert. Harman's patent law expert, Lawrence M. Sung, provided an opinion on the materiality of the field trials. Exh. 22 at 18-20. However, Mr. Sung is neither a technical expert nor person of ordinary skill in the art under either MIT or Harman's proposed definition, Exh. 22 at 3-5; Exh. 23 at ¶¶ 36-37, and is not technically qualified to render independent opinions on the materiality of information he has relied upon. Exh. 23 at ¶ 36.

25. The opinion of MIT's navigation expert, Dr. Cannon, stands unrebutted on the issue of the materiality of the field trials.

26. The field trials or test drives did not constitute public use of the Back Seat Driver. Exh. 6 at ¶ 13; Exh. 21 at ¶ 120.

<u>The Thesis</u>

27. Drafts of Jim Davis' Ph.D. thesis were not publicly distributed. Exh. 8 at 116:23-117:7; *see also* Exh. 4 at ¶ 6; Exh. 5 at ¶ 7.

28. Only Jim Davis and Chris Schmandt had the password to the computer that was storing drafts of Jim Davis' thesis at the MIT Media Lab. Exh. 8 at 113:15-23; Exh. 4 at ¶ 3.

29. The computer that stored drafts of Jim Davis' thesis was secured in a locked room that had keypad access. Exh. 8 at 113:20-23; Exh. 4 at ¶ 4.

30. Jim Davis did not print copies of his thesis or drafts and give them to the general public. Exh. 5 at ¶ 2; Exh. 8 at 116:23-117:7; *see also* Exh. 4 at ¶ 3.

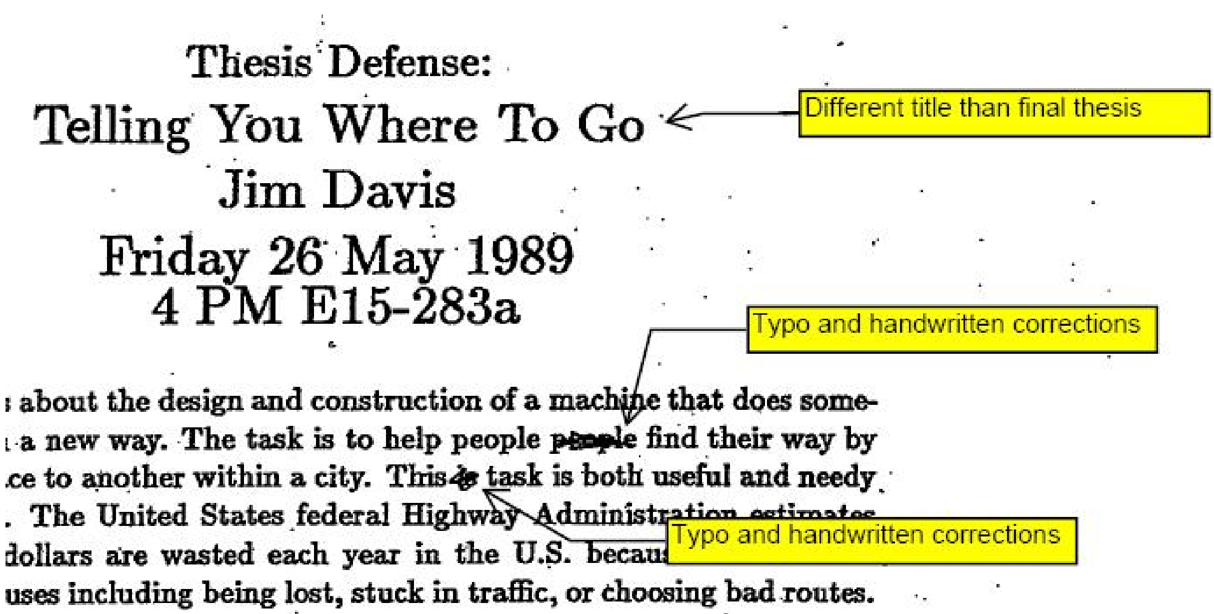
31. Jim Davis defended his thesis sometime in the fall of 1989 after continued development and field trials conducted in the summer of 1989. Exh. 4 at ¶ 7; Exh. 5 at ¶ 6.

32. Jim Davis' defense of his thesis to a limited audience and at which copies of Jim Davis' thesis were not distributed do not constitute a patentability bar. Exh. 6 at ¶ 10.

33. After Davis completed his thesis in August 1989, the thesis was sent to the MIT library for cataloging, and the thesis was shelved in February 1990, less than one year before the filing date of the '685 patent. Exh. 8 at 113:4-12; Exh. 2 at 376; Exh. 3 at 712-713.

34. Prior to its publication in the MIT library, the only people who would have received drafts or a finalized version of Jim Davis' thesis would have been actual members of Jim Davis' thesis committee or colleagues acting in an academic advisory capacity. Exh. 5 at ¶ 7.

35. The "flyer" Harman relies on to "show" that Jim Davis defended his thesis on May 26, 1989 is a draft, Exh. 5 at ¶ 6:


Thesis Defense:
Telling You Where To Go
Jim Davis
Friday 26 May 1989
4 PM E15-283a

about the design and construction of a machine that does some-
a new way. The task is to help people ~~people~~ find their way by
ce to another within a city. This ~~is~~ task is both useful and needy.
. The United States federal Highway Administration estimates
dollars are wasted each year in the U.S. becau
uses including being lost, stuck in traffic, or choosing bad routes.

36. Jim Davis' thesis defense did not occur in Room E15-283a. Exh. 4 at ¶ 7.

37. Jim Davis did not defend his thesis on May 26, 1989. Exh. 4 at ¶ 7; Exh. 5 at ¶ 6.

38. Jim Davis was not ready to defend his thesis in May of 1989. Exh. 5 at ¶ 6.

39. The May 26, 1989 draft was created at a time when Jim Davis thought he might be able to graduate in June of 1989. Exh. 5 at ¶ 6.

40. Because Jim Davis' thesis was not a "printed publication" or "publicly available" before the critical date of the '685 patent, the thesis could not "anticipate" the claims of the '685 patent. Exh. 6 at ¶ 6; Exh. 2 at 376.

41. NEC did not have any expectation of patent rights in the Back Seat Driver beyond those provided by MIT's standard licensing policy. Exh. 9 at 40:17-21.

42. NEC received a non-exclusive license to the '685 patent under standard MIT policy. Exh. 4 at ¶ 6; Exh. 9 at 251:7-13.

43. Phil Rittmueller did not receive a copy of the "Back Seat Driver Final Report," which bore a date of July 31, 1989, and attachments thereto, until after Jim Davis' thesis was completed. Exh. 9 at 149:4-16, 150:24-154:21; Exh. 5 at ¶ 3.

44. Phil Rittmueller did not receive a copy of Jim Davis' thesis before Jim Davis finished the thesis. Exh. 9 at 64:13-65:19.

45. Phil Rittmueller did not receive a copy of Jim Davis' thesis until after the thesis was available in MIT's library. Exh. 9 at 153:24-154:21; Exh. 4 at ¶ 5.

46. Phil Rittmueller understood that communications with Jim Davis and Chris Schmandt were confidential or "close to the vest." Exh. 9 at 303:3-12, 305:23-306:5; Exh. 4 at ¶ 6.

47. The public did not have access to copies of Jim Davis' thesis until the thesis was shelved in MIT's library. Exh. 4 at ¶ 8; Exh. 8 at 113: 5-12.

48. Any copies of Jim Davis' thesis that were sent to Lynn Streeter were done so with a view towards obtaining feedback from a professional colleague in an advisory role. Exh. 5 at ¶ 4.

49. Lynn Streeter recognized academic and ethical obligations kept Jim Davis' thesis from being publicly available. Exh. 7 at ¶¶ 3, 7.

50. Formal "restrictions" regarding confidentiality were not necessary because Lynn Streeter was a colleague of Jim Davis and Chris Schmandt. Exh. 5 at ¶ 4.

51. A limited distribution of Jim Davis' thesis to close colleagues does not make the thesis "publicly available," a "publication," or otherwise bar patentability. Exh. 6 at ¶ 9.

52. Drafts of Jim Davis' thesis were not available or distributed publicly. Exh. 8 at 113:13-21, 116:23-117:7; Exh. 4 at ¶ 3.

<u>MIT's Counter-Statement of Facts to Harman's Statement of Facts</u>

1. Harman's SOF 1: "In the late 1980's, Jim Davis was a graduate student at MIT working within the Speech Resources Group of the MIT Media Lab under his faculty advisor, Chris Schmandt, who also served as the Director of that Group." Harman's SOF ¶ 1.

MIT does not dispute this.

2. Harman' SOF 2: "By early 1988, Davis and Schmandt were working on a project called the Back Seat Driver that involved automobile navigation using spoken instructions."

MIT does not dispute this.

3. Harman's SOF 3: "The Back Seat Driver became Davis' thesis for his doctorate degree and eventually led to the patent application that issued as the '685 Patent."

MIT does not dispute this.

4. Harman's SOF 4: "A subsidiary of the large, Japanese corporation NEC funded the project."

MIT agrees that a subsidiary of NEC funded the Back Seat Driver research.

5. Harman's SOF 5: "Schmandt testified that while Davis was working on his thesis, and even after he finished drafting it, Davis 'could print a copy [of it] whenever he wanted and give that to anybody that he wanted to."

MIT disagrees with Harman's characterization of Chris Schmandt's testimony. All Schmandt testified to was the fact that Davis controlled availability of his thesis. Chris Schmandt did not testify that Jim Davis actually *did* print and distribute drafts of his thesis. Schmandt further testified that MIT's policy was not to distribute thesis drafts publicly. Exh. 4 at ¶ 3; Exh. 5 at ¶ 2.

6. Harman's SOF 6: "On July 31, 1989, Davis and Schmandt sent a copy of the completed thesis ('certified by Nicholas P. Negroponte', the then Director of the MIT Media Lab) to a Mr. Rittmueller, an NEC employee at the time."

MIT disputes this statement. There is no evidence that a copy of Jim Davis' thesis was sent to Mr. Phil Rittmueller on July 31, 1989. In fact, the evidence is that Phil Rittmueller did not receive a copy of Jim Davis' thesis until after it was shelved in the MIT library. Exh. 9 at 153:24-154:21; Exh. 4 at ¶ 5; Exh. 5 at ¶ 3.

7. Harman's SOF 7: "The copy of Davis' thesis sent to Rittmueller was not marked confidential in any way."

MIT does not dispute that the copy of Jim Davis' thesis produced from Phil Rittmueller's file was not marked confidential. MIT disputes the inferences Harman seeks to have drawn from this fact. The thesis would not have been stamped confidential, because Mr. Rittmueller did not

receive a copy of the thesis until after it was published. Exh. 9 at 64:13-65:19, 153:24-154:21; Exh. 4 at ¶ 5. Additionally, explicit confidentiality markings were not necessary between MIT and NEC because NEC sponsored the Back Seat Driver research, and correspondence between MIT and NEC was not public. Exh. 9 at 302:23-303:12, 305:22-306:5; Exh. 4 at ¶ 6.

8. Harman's SOF 7: "Davis himself sent another copy of his thesis (unsigned but bearing an August 4, 1989 date for Davis' signature) to a Bell Labs employee, Lynn Streeter, without any confidentiality designation and without any restrictions on her use of it."

MIT disputes the statement. Lynn Streeter believes she did not receive the thesis until the thesis was defended and the thesis was public. Exh. 7 at ¶ 8. In addition, while no written agreement was provided to Lynn Streeter, none was necessary because she was an academic colleague, and thus, formal confidentiality agreements were unnecessary. Exh. 7 at ¶¶ 7-8. Davis would have provided a copy to Lynn Streeter based on the understanding that he was doing so as an academic colleague and not for publication, so formal confidentiality markings were unnecessary. Exh. 5 at ¶ 8.

9. Harman's SOF 9: "Dr. Streeter recalls receiving it 'the day it was published,' which she further recalls was when her Bell Labs' co-worker who also served on Davis' thesis committee '[had] actually gone up for the defense [of the Davis thesis] or something and I know I got the thesis just about the same time.'"

MIT disputes this statement. Lynn Streeter did not testify that she received a copy of the thesis the "day it was published" but instead "about the same time" as the thesis defense. Exh. 10 at 7:23-8:21; 115:21-25.

10. Harman's SOF 10: Harman says "In May 1989, after requesting from Davis a copy of 'any papers [Davis had] written about [the Back Seat Driver],' a University of Minnesota student

responded to Davis that she could 'wait a couple weeks to see [Davis' T]hesis."

MIT disputes the inference Harman seeks to draw here. Jim Davis did not send a copy of his thesis to this student in May 1989. Exh. 5 at ¶ 5.

11. Harman's SOF 11: "The words, lines, and pages of the copies of sent to Dr. Streeter and Mr. Rittmueller are identical to the copy that MIT later submitted to the PTO; only the signature on the Rittmueller copy differs."

MIT does not dispute this.

12. Harman's SOF 12: "By May 26, 1989, Davis was prepared to defend his thesis and invited the public to attend."

MIT disputes this. There is no evidence in support of this statement. In, fact, Jim Davis was not prepared to defend his thesis on May 26, 1989. Exh. 4 at 7; Exh. 5 at ¶ 6. Jim Davis' thesis was not ready for defense until fall 1989 and Jim Davis worked on the thesis and research prototypes through the summer of 1989. Exh. 4 at 7; Exh. 5 at ¶ 6.

13. Harman's SOF 13: "MIT had a policy forbidding secrecy and encouraging the free sharing of information in 1989."

MIT disputes this statement, and the inferences Harman seeks to draw from the role of a university to disseminate information. There are academic and integrity reasons why drafts of theses are not public documents or other documents not ready for public distribution. The general public did not have access to Jim Davis' thesis until it was shelved in the MIT library. Exh. 4 at ¶ 8; Exh. 8 at 113:5-12, 117:4-7.

14. Harman's SOF 14: "Davis signed and submitted his thesis on August 4, 1989."

MIT does not dispute this.

15. Harman's SOF 15: "On August 9, 1990 MIT filed a patent application, based on Davis' thesis, that became the '685 Patent."

MIT does not dispute this.

16. Harman's SOF 16: "MIT had more than 800 U.S. patents already issued in its name by the August 9, 1990 filing date of the '685 application."

MIT does not dispute this, but believes the fact is irrelevant.

17. Harman's SOF 17: "On August 16, 1991, NEC raised concerns about MIT's prosecution of the '685 Patent."

MIT agrees that Phil Rittmueller on behalf of NEC wrote a letter dated August 16, 1991 discussing the prosecution of the Back Seat Driver patent.

18. Harman's SOF 18: Harman says "NEC was upset and unhappy that MIT's publicity of the Back Seat Driver had caused NEC to waste considerable time and effort only to lose any foreign patent rights it may have had."

MIT disputes this statement of fact, and the inferences Harman seeks to draw from the correspondence. In fact, NEC was not unhappy with MIT and continued to sponsor MIT after the Back Seat Driver patent was granted. Exh. 4 at ¶ 9.

19. Harman's SOF 19: Harman says "NEC wanted its outside patent counsel to monitor and participate in the prosecution."

MIT does not dispute that there is a document in which NEC made this statement. MIT disputes that any inferences relevant to this matter can be drawn from this document.

20. Harman's SOF 20: "MIT (via the same Nicholas Negroponte who certified Davis' thesis in 1989) expressed concerns internally about NEC being an 'unhappy customer' who had been 'particularly generous with MIT.'"

MIT does not dispute that there is a document in which Professor Negroponte made these statements. MIT disputes that any inferences relevant to this matter can be drawn from this document.

21. Harman's SOF 21: "On November 8, 1991, the PTO rejected each and every pending claim because the thesis was publicly available more than one year before MIT filed the patent application."

MIT disputes this statement. In fact, the Patent Examiner erroneously believed that Jim Davis' thesis was available more than one year before the filing date of the '685 patent, and the rejection was based on that erroneous belief. MIT subsequently corrected the Examiner's erroneous belief. Exh. 2 at 376.

22. Harman's SOF 22: "MIT told NEC that they had an opportunity to alleviate NEC's concerns."

MIT disputes this statement of fact. MIT never offered to "alleviate" NEC's concerns, which connotes acting unethically to do so.

23. Harman's SOF 23: "MIT expressly acknowledged to the PTO that it clearly understood the Examiner's reasons for rejection."

MIT disputes this statement of fact. MIT did not expressly acknowledge or concede the correctness of the Examiner's reasons for rejecting the '685 patent. Exh. 6 at ¶ 7.

24. Harman's SOF 24: Harman says "In its Response to the First Office Action, MIT did not challenge the materiality of Davis' thesis or the Examiner's determination that the thesis anticipated each claim."

MIT disputes this statement of fact. In fact, MIT challenged the materiality of the thesis

on its face and presented evidence that the thesis was not prior art under 35 U.S.C. § 102 -- meaning it was not material. Exh. 6 at ¶ 6.

25. Harman's SOF 25: "In its Response to the First Office Action, MIT submitted a new title page for the thesis that was stamped by MIT's library."

MIT does not dispute that it submitted the title page with the MIT library stamp. MIT disputes any inference Harman seeks to draw from the reference to the title page being "new."

26. Harman's SOF 26: "In its Response to the First Office Action, MIT told the PTO that Davis' thesis 'did not become available to the public more than a year before the filing date of the present application."

MIT does not dispute this.

27. Harman's SOF 27: Harman says "In its Response to the First Office Action, MIT led the PTO to believe that the only access to Davis' thesis was through the MIT library."

MIT disputes this statement of fact. MIT did not state that the only access was through the library. MIT stated that the thesis did not become publicly available on August 4, 1989 and that the MIT library generally did not catalog and shelve theses for several months after the theses were received. Exh. 6 at ¶ 8. MIT disputes any inference Harman seeks to bring suggesting that MIT mislead the Patent Office into believing that no one other than Dr. Davis had seen the thesis before the library catalogued it.

28. Harman's SOF 28: "When MIT submitted its Response to the First Office Action, MIT knew that Davis 'could print a copy whenever he wanted and give that to anybody that he wanted to.'"

MIT disputes this statement of fact to the extent it seeks to draw an inference of improper

or misleading statements. The fact that Dr. Davis legally could give the thesis to anyone does not lead to an inference that he actually did.

29. Harman's SOF 29: "When MIT submitted its Response to the First Office Action, MIT knew that Davis had actually distributed his thesis and that he did so more than once."

MIT disputes this statement of fact. If "distributed" is intended to imply that Dr. Davis made his thesis freely and publicly available, then the statement is false. Jim Davis provided a copy only to close colleagues or advisors, like those on his thesis committee. Exh. 5 at ¶ 7. A limited distribution to close colleagues and advisors does not constitute a patentability bar. Exh. 6 at ¶ 9.

30. Harman's SOF 30: "When MIT submitted its Response to the First Office Action, MIT knew that Davis publicly defended his thesis."

MIT does not dispute the statement of fact, but disputes the inference that Harman seeks to suggest that something improper was withheld. Jim Davis' defense of his thesis does not constitute a patentability bar. Exh. 6 at ¶ 10.

31. Harman's SOF 31: "When disclosing information that MIT did 'want to be considered and made of record,' in an IDS received by the PTO on September 4, 1990, MIT said nothing about the availability of Davis' thesis."

MIT disputes this statement of fact as misleading. MIT provided the Patent Office with a copy of Jim Davis' thesis in the September 4, 1990 IDS. Exh. 2 at 346.

32. Harman's SOF 32: "The PTO issued a Notice of Allowance for the '685 patent on June 30, 1992."

MIT does not dispute this.

33. Harman's SOF 33: "MIT told NEC on July 13, 1992 that 'it was MIT's pleasure to inform [NEC]…that the patent application on the [Back Seat Driver] case has been allowed.'"

MIT does not dispute this.

34. Harman's SOF 34: "MIT asserted privilege and forced Harman to move to compel the documents (MIT07377-07406) showing NEC's concerns over the Back Seat Driver patent application."

MIT does not dispute that documents MIT07377-07406 were produced in response to a Court order. MIT disputes the characterization of the motion or the documents.

35. Harman's SOF 35: "Documents bearing Bates Nos. STREETER 52-729 were produced from Dr. Streeter's files in response to a subpoena that Harman served on Dr. Streeter. Litigation counsel for MIT representing MIT in this matter represented Dr. Streeter in regard to the subpoena."

MIT does not dispute this.

36. Harman's SOF 36: "Documents bearing Bates Nos. RITTMUELLER 1-351 were produced from Mr. Rittmueller's files in response to a subpoena that Harman served on Mr. Rittmueller. Litigation counsel for MIT representing MIT in this matter represented Dr. Rittmueller in regard to the subpoena."

MIT does not dispute this.

37. Harman's SOF 37: "Documents bearing Bates Nos. HAR 709859-710072 were produced by Harman after learning about them from a corporate partner in its counsel's law firm who happened to work on the Back Seat Driver while an undergraduate student at MIT."

MIT has no basis to confirm or deny this statement. Harman has represented that it will

not call this Kirkland partner to testify, and therefore, any evidence relating to his private files is inadmissible and hearsay.

38. Harman's SOF 38: "MIT had an 'eye toward litigation' extending back to 1989 giving rise to privilege and thus triggering its continuing obligation to preserve documents."

This is purely legal argument that MIT need not respond to in a statement of facts. Nevertheless, MIT believes it has fully complied with all of its discovery obligations.

39. Harman's SOF 39: "By April 30, 1989, '[t]he Back Seat Driver [was] working, and working well' and had 'made dozens of successful trips' on the public streets around the Boston area."

MIT disagrees that this statement shows that the Back Seat Driver was perfected, bug-free, and fully operational. At best, the statement shows that the inventors were "confident" that the system would work well enough for Dr. Davis' thesis. Exh. 11 at 169:4-11.

40. Harman's SOF 40: "By April 30, 1989, Davis and Schmandt were 'eager to demonstrate it' and had already done so many times."

MIT disputes the statement of fact, to the extent it seeks to imply widespread public disclosure.

41. Harman's SOF 41: Harman says "Between May 1 and July 31, 1989, at least '50 subjects' used the Back Seat Driver to navigate the public streets of Boston."

MIT does not dispute that students were used to help develop the system. MIT objects to the inference that these field trials were demonstrations to the public, or that they amounted to "use" of the Back Seat Driver within the meaning of the patent statute. Exh. 21 at ¶¶ 118-120.

42. Harman's SOF 42: "Among the subjects who used the Back Seat Driver were a Bell Labs employee, one or more NEC employees, two MIT undergraduate students, and several

General Motors' employees none of whom signed any type of confidentiality agreement or were bound by any confidentiality obligation."

MIT disputes the statement of fact. The people who took test drives were obligated by ethical and academic considerations regarding the field trials. In any event, since field trials and test drives do not constitute public use of the invention, confidentiality agreements were not necessary. Exh. 21 at ¶¶ 118-120; Exh. 18 at 6763, Exh. 19 at 6765.

43. Harman's SOF 43: "Not a single confidentiality agreement for any use or demonstration of the Back Seat Driver prototype has been produced in this litigation."

MIT does not dispute this. MIT objects to the inference Harman seeks to draw that confidentiality agreements were somehow required. Confidentiality agreements are not controlling because field trials were not public uses of the invention.

44. Harman's SOF 44: "MIT openly used the Back Seat Driver all over Boston and stored it in a public garage."

MIT disputes this statement of act. The evidence is that MIT stored the Back Seat Driver prototype in an MIT garage that had limited card-only access. Exh. 24 at 160:22-161:2. In addition, even when the car was on a public road, no one in the public would have noticed the invention, which was entirely internal to the vehicle. Exh. 21 at ¶¶ 118-120.

45. Harman's SOF 45: "MIT never told the PTO about the 50 subjects who used the Back Seat Driver to navigate the public streets of Boston more than a year before MIT filed the patent application."

MIT disputes this statement of fact. MIT provided four references, in addition to the patent application itself, that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh.

14 at 459; Exh. 15 at 938. In any event, MIT was not required to tell the Patent Office about the field trials because the field trials were not public uses of the invention. Exh. 6 at ¶¶ 12-13; Exh. 21 at ¶ 120.

46. Harman's SOF 46: "In MIT's first IDS it withheld information about the 50 public uses of the Back Seat Driver."

MIT disputes this statement of fact. MIT provided four references with the IDS that mentioned the field trials or test drives of the Back Seat Driver prototype. Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938.

47. Harman's SOF 47: "MIT never told the PTO that it reduced to practice the sole independent claim and 22 dependent claims 'at least as early as June of 1989.'"

MIT was not required to tell the Patent Office when the claims were reduced to practice. Exh. 6 at ¶ 11.

48. Harman's SOF 48: "MIT never told the PTO that [it] reduced to practice 23 more dependent claims 'at least as early as August 4, 1989.'"

MIT was not required to tell the Patent Office when the claims were reduced to practice. Exh. 6 at ¶ 11.

49. Harman's SOF 49: "MIT never told the PTO that public uses continued after the claimed subject matter was reduced to practice."

MIT disputes this statement of fact. There were no public uses to disclose to Patent Office. MIT was not required to tell the Patent Office about the field trials because the field trials were not public or public uses. Exh. 6 at ¶ 12-13; Exh. 21 at ¶¶ 118-120.

50. Harman's SOF 50: "MIT never told the PTO anything about the timing of the public uses."

MIT disputes this statement of fact. First, there were no public uses to disclose to the patent office. Second, MIT provided four references, in addition to the patent application itself, that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface, and MIT provided dates for the references. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938.

51. Harman's SOF 51: "MIT never told the PTO anything about the extent of the public uses."

MIT disputes this statement of fact. First, there were no public uses to disclose to the patent office. Second, MIT provided four references, in addition to the patent application itself, that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface, and MIT provided dates for the references. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938.

52. Harman's SOF 52: "MIT never told the PTO anything about the details surrounding the public uses."

MIT disputes this statement of fact. First, there were no public uses to disclose to the patent office. Second, MIT provided four references, in addition to the patent application itself, that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface, and MIT provided dates for the references. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938.

53. Harman's SOF 53: "MIT never told the PTO anything about the lack of confidentiality regarding the public uses."

MIT disputes this statement of fact. First, there were no public uses to disclose to the patent office. Second, MIT provided four references, in addition to the patent application itself,

that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface, and MIT provided dates for the references. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938.

54. Harman's SOF 54: "MIT only disclosed to the PTO that 'An actual working prototype of the Back Seat Driver has been implemented. It has successfully guided drivers unfamiliar with Cambridge, Mass. to their destination. It is easy to foresee a practical implementation in the future."

MIT disputes this statement of fact. MIT provided three additional references that mentioned field trials or test drives of the Back Seat Driver prototype to test the interface. Exh. 1 at cover page, 3:4-7; Exh. 12 at 1101; Exh. 13 at 933; Exh. 14 at 459; Exh. 15 at 938. The Patent Examiner considered these references. Exh. 2 at 375-76.

55. Harman's SOF 55: "MIT's patent prosecution attorney testified that if '[the Back Seat Driver] was in use more than one year prior to the date of the filing of the ['685] application, then [that use] would have been relevant to the PTO.'"

This passage is taken out of context and is not a concession that the Back Seat Driver field trials were invalidating public uses of the invention. Exh. 6 at ¶ 13.

56. Harman's SOF 56: "MIT's prosecuting attorney made no effort to investigate the public uses of the 'prototypes' disclosed in the specification."

MIT disputes this statement of fact. The statement Harman uses to support this "fact" comes from Mr. Pasternack's deposition testimony relating to his document production in connection with this litigation, not prosecution of the '685 patent. Exh. 6 at ¶ 14.

57. Harman's SOF 57: "During prosecution of the '685 Patent, Davis knew that 50 subjects had used the Back Seat Driver between May 1, 1989 and July 31, 1989 and after Davis knew the

Back Seat Driver would work."

Harman does not specify which version of the Back Seat Driver prototype Davis' testimony refers to. Jim Davis and Chris Schmandt continued to test the Back Seat Driver prototype to for durability, safety, and repeatability reasons.

58. Harman's SOF 58: "During prosecution of the '685 Patent, Davis knew that he had continued to use the Back Seat Driver with 50 subjects after he knew the invention would work."

Harman mischaracterizes Jim Davis' testimony, in which he indicated that he was "confident" the prototype would work. Exh. 5 at ¶ 9; Exh. 11 at 169:4-11. The test subjects were not shown how the Back Seat Driver system worked. Exh. 5 at ¶ 9.

59. Harman's SOF 59: "During prosecution of the '685 Patent, Schmandt knew that 50 subjects had used the Back Seat Driver between May 1, 1989 and July 31, 1989."

The field trials of the Back Seat Driver prototype were not public uses of the invention. Exh. 21 at ¶¶ 118-120.

May 25, 2007

Respectfully Submitted,

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CERTIFICATE OF SERVICE

I certify that on May 25, 2007, I caused a copy of the forgoing document to be served upon counsel of record for Harman International Industries by electronic mail and Federal Express overnight delivery.

/s/ Steven M. Bauer
Steven M. Bauer

EXHIBIT 1

US005177685A

United States Patent [19]

Davis et al.

[11] Patent Number: 5,177,685

[45] Date of Patent: Jan. 5, 1993

[54] AUTOMOBILE NAVIGATION SYSTEM USING REAL TIME SPOKEN DRIVING INSTRUCTIONS

[75] Inventors: James R. Davis, North Cambridge; Christopher M. Schmandt, Milton, both of Mass.

[73] Assignee: Massachusetts Institute of Technology, Cambridge, Mass.

[21] Appl. No.: 565,274

[22] Filed: Aug. 9, 1990

[51] Int. Cl.[5] G01C 21/00

[52] U.S. Cl. 364/443; 340/988; 364/449; 364/453

[58] Field of Search 340/988, 989, 990, 995; 364/443, 444, 449, 450, 453, 436

[56] References Cited

U.S. PATENT DOCUMENTS

4,139,889	2/1979	Ingels	340/989 X
4,697,281	9/1987	O'Sullivan	455/33 X
4,734,863	3/1988	Honey et al.	340/988 X
4,796,191	1/1989	Honey et al.	364/450
4,812,843	3/1989	Champion, III et al.	340/989 X
4,882,696	11/1989	Nimura et al.	
4,891,761	1/1990	Gray et al.	364/449 X
4,926,336	5/1990	Yamada	364/444

(List continued on next page.)

OTHER PUBLICATIONS

"Synthetic Speech for Real Time Direction-Giving", C. M. Schmandt et al., Digest of Technical Papers, International Conference on Consumer Electronics, Rosemont, Ill., Jun. 6-9, 1989.

"Synthetic Speech for Real Time Direction Giving", C. M. Schmandt et al., IEEE Transactions on Consumer Electronics, 35(3):649-653, Aug. 1989.

"The Back Seat Driver: Real Time Spoken Driving Instructions", J. R. Davis et al., Proceedings of the IEEE Vehicle Navigation and Information Systems Conference, Toronto, Canada, Sep. 1989.

"Back Seat Driver: Voice Assisted Automobile Navigation", by J. R. Davis, Ph.D. Thesis, Massachusetts Institute of Technology, Sep., 1989.

"CD-ROM Assisted Navigation Systems", by O. Ono et al., Digest of Technical Papers, IEEE International Conference on Consumer Electronics, Rosemont, Ill., Jun. 8-10, 1988.

"Attention, Intentions, and the Structure of Discourse", by B. J. Grosz and C. L. Sidner (Computational Linguistics, 12(3):175-204, 1986.

"The Intonational Structuring of Discourse", by J. Hirschberg et al., Proceedings of the Association for Computational Linguistics, 136-144, Jul. 1986.

Automobile Electronic News, vol. 1, No. 16., "U.K. Picks GEC to Head Navigation Project", by James Fallon, Aug. 28, 1989.

"Softening of the Arteries", by Bruce Weber, The New York Times Magazine, p. 78, Aug. 26, 1990.

"Terminal Back Seat Driver", Technology Review, Jul., 1990, p. 10.

(List continued on next page.)

Primary Examiner—Parshotam S. Lall

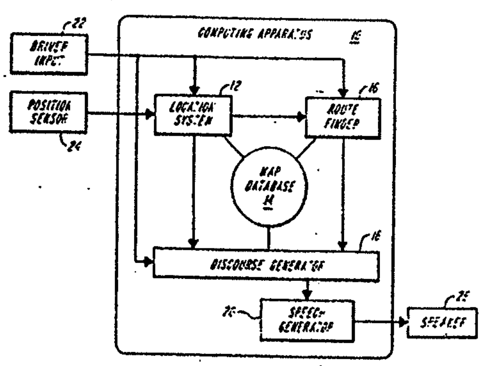
Assistant Examiner—Edward Pipala

Attorney, Agent, or Firm—Choate, Hall & Stewart

[57] ABSTRACT

An automobile navigation system which provides spoken instructions to the driver of an automobile to guide the driver along a route is disclosed. The heart of the system is a computing apparatus comprising a map database, route finding algorithms, a vehicle location system, discourse generating programs, and speech generating programs. Driver input means allows the driver to enter information such as a desired destination. The route finding algorithms in the computer apparatus calculate a route to the destination. The vehicle location system accepts input from a position sensor which measures automobile movement (magnitude and direction) continuously, and using this data in conjunction with the map database, determines the position of the automobile. Based on the current position of the automobile and the route, the discourse generating programs compose driving instructions and other messages according to a discourse model in real time as they are needed. The instructions and messages are sent to voice generating apparatus which conveys them to the driver.

58 Claims, 3 Drawing Sheets



U.S. PATENT DOCUMENTS

4,937,751	6/1990	Nimura et al.	364/444 X
4,939,662	7/1990	Nimura et al.	340/990 X
4,951,211	8/1990	De Villeroche	364/444
4,954,958	9/1990	Savage et al.	364/444
4,984,168	1/1991	Neukrichner et al.	364/449
4,992,947	2/1991	Nimura et al.	364/444
5,021,961	6/1991	Ross et al.	340/990 X
5,041,983	8/1991	Nakahara et al.	364/449
5,043,902	8/1991	Yokoyama et al.	364/449

OTHER PUBLICATIONS

"Taxi! Dynamic Cartographic Software for Training Cab Drivers", by M. Bosworth et al., Technical Report, Hunter College Department of Geology and Geography, (212)-772-4000, 1988 paper presented at the Annual Meeting of the Association of American Geographers.

"Digital Map Dependent Functions of Automatic Vehicle Location Systems", by C. B. Harris et al., IEEE Position and Location Symposium, pp. 79-87, 1988, IEEE CH2675-7.

"Digital Maps on Compact Discs", by H. J. G. M. Benning, Technical Paper Series 860125, Society of Automobile Engineers, 1986.

"Eva: An Electronic Traffic Pilot for Motorists", by O. Pilsak, Technical Papers Series 860346, Society of Automotive Engineers, 1986.

"Digital Map Data Bases for Autonomous Vehicle Navigation Systems", by E. P. Neukirchner et al., IEEE Position and Location Symposium, pp. 320-324, 1986, IEEE 86CH2365-5.

"Applications of the Compact Disc in Car Information and Navigation Systems", by M. L. G. Thoone et al., Technical Papers Series 840156, Society of Automotive Engineers, 1984.

"On Board Computer System for Navigation, Orientation, and Route Optimization", by P. Haeussermann, Technical Paper Series 840483, Society of Automotive Engineers, 1984.

"Electro Gryo-Cator: New Inertial Navigation System for Use in Automobiles", by K. Tagami et al., Technical Paper Series 830659, Soc. of Automotive Engineers, 1983.

"Navigation Systems Using gps for Vehicles", by T. Itoh, et al., Technical Paper Series 861360, Society of Automotive Engineers, 1986.

"Extending Low Cost Land Navigation Into Systems Information Distribution and Control", by S. K. Honey et al., IEEE Position and Locations Symposium, pp. 439-444, 1986, IEEE 86CH2365-5.

"Map Matching Augmented Dead Reckoning", by W. B. Zavoli et al., Proceedings of the 35th IEEE Vehicular Technology Conference, pp. 359-444, 1986, IEEE CH2308-5.

"Automated Provision of Navigation Assistance to Drivers", by Matthew McGranaghan et al., The American cartographer 14(2):121-138, 1987.

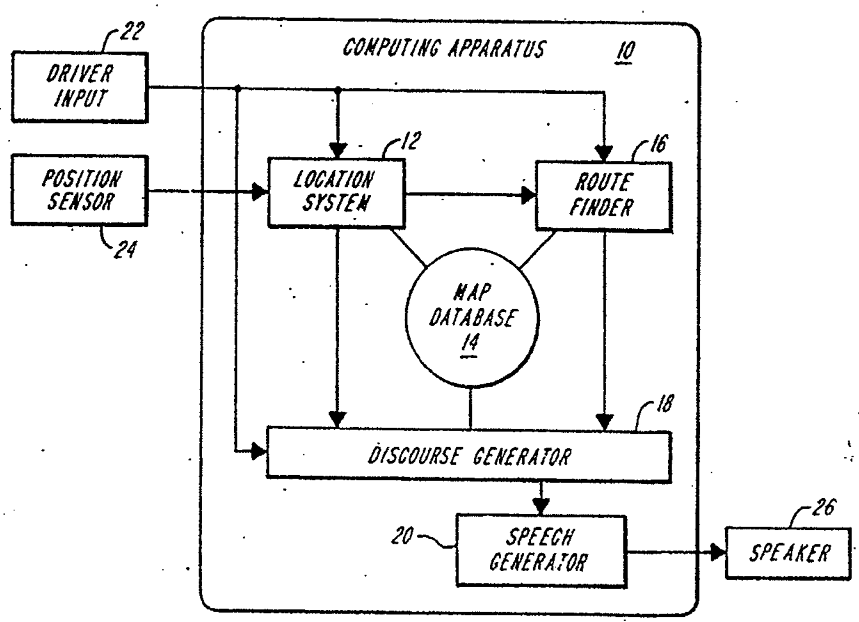

22
DRIVER INPUT
POSITION SENSOR
24
COMPUTING APPARATUS
10
12
LOCATION SYSTEM
16
ROUTE FINDER
MAP DATABASE 14
18
DISCOURSE GENERATOR
20
SPEECH GENERATOR
26
SPEAKER

FIG. 1

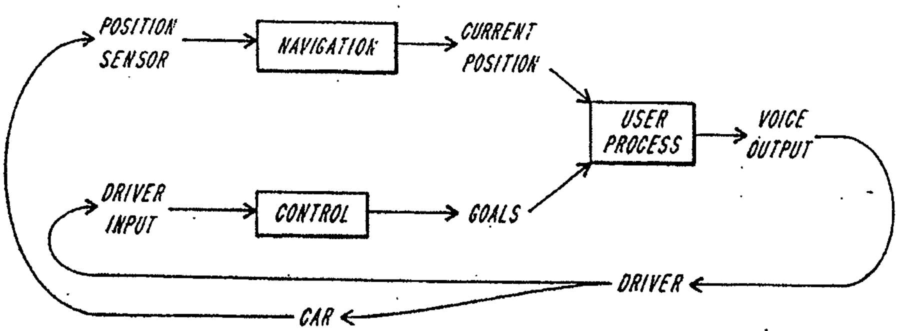

POSITION SENSOR
NAVIGATION
CURRENT POSITION
USER PROCESS
VOICE OUTPUT
DRIVER INPUT
CONTROL
GOALS
DRIVER
CAR

FIG. 2

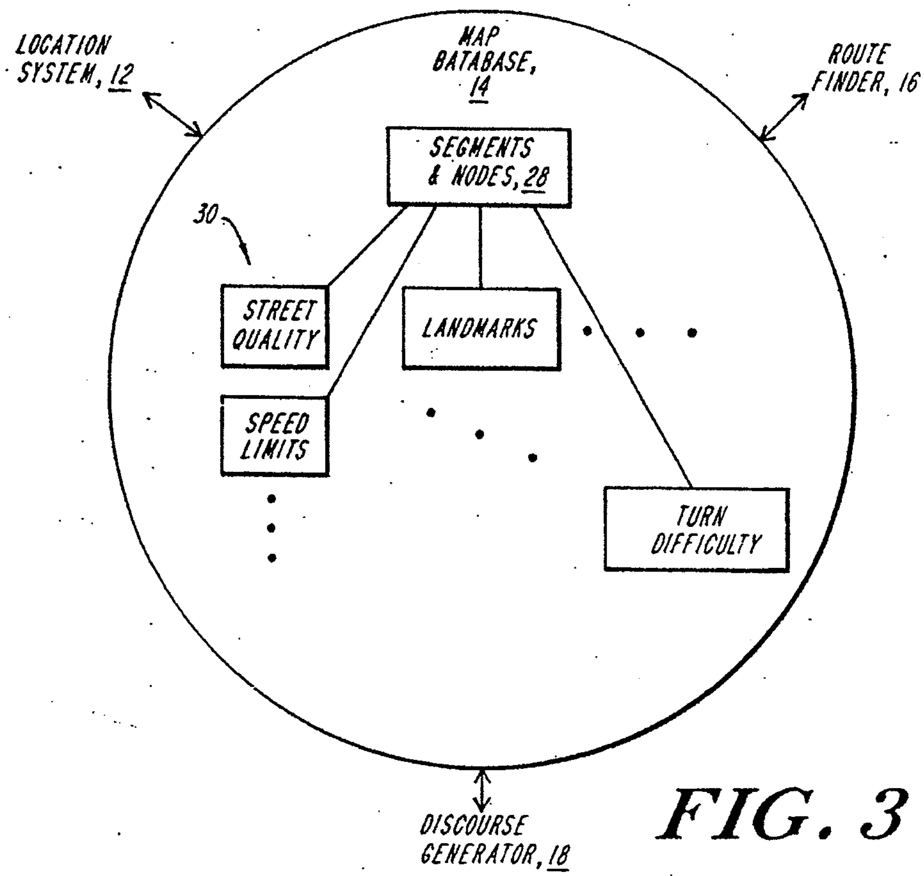

LOCATION SYSTEM, 12
MAP DATABASE, 14
ROUTE FINDER, 16
SEGMENTS & NODES, 28
30
STREET QUALITY
LANDMARKS
SPEED LIMITS
TURN DIFFICULTY
DISCOURSE GENERATOR, 18

FIG. 3

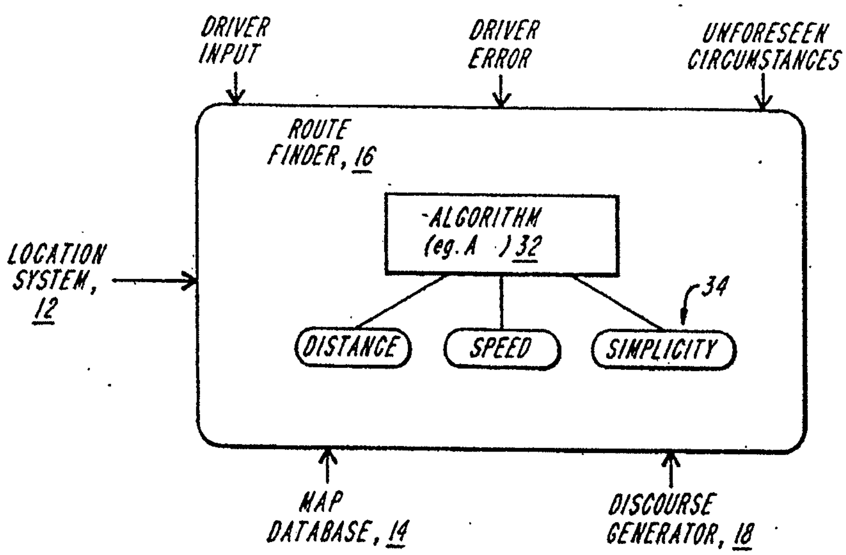

DRIVER INPUT
DRIVER ERROR
UNFORESEEN CIRCUMSTANCES
ROUTE FINDER, 16
ALGORITHM (eg. A) 32
34
LOCATION SYSTEM, 12
DISTANCE
SPEED
SIMPLICITY
MAP DATABASE, 14
DISCOURSE GENERATOR, 18

FIG. 4

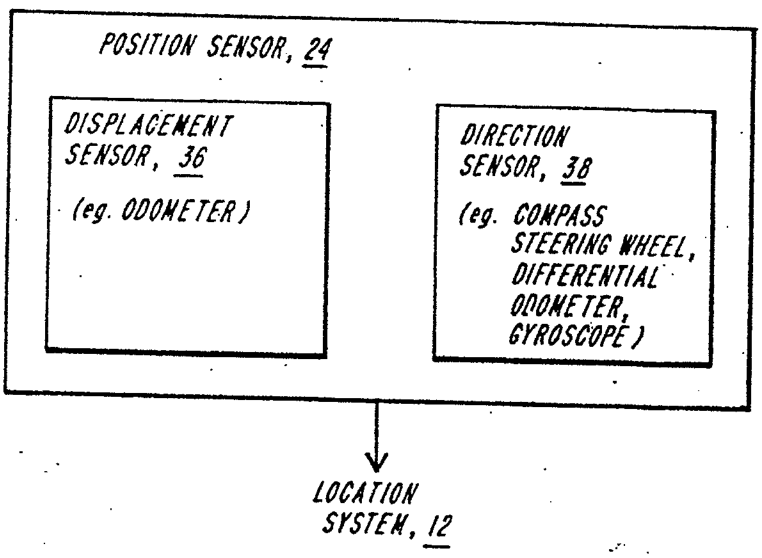

POSITION SENSOR, 24
DISPLACEMENT SENSOR, 36
(eg. ODOMETER)
DIRECTION SENSOR, 38
(eg. COMPASS STEERING WHEEL, DIFFERENTIAL ODOMETER, GYROSCOPE)
LOCATION SYSTEM, 12

FIG. 5

AUTOMOBILE NAVIGATION SYSTEM USING REAL TIME SPOKEN DRIVING INSTRUCTIONS

BACKGROUND OF THE INVENTION

This invention relates to computerized automobile navigation systems, particularly to a system which calculates a route to a destination, tracks automobile location, and provides spoken instructions to the driver in real time as they are needed.

Navigation systems can be classified into three categories:

Positioning systems tell you where you are.

Orienting systems show the direction of your destination.

Instructional systems tell you what to do to get to your destination.

A navigation system can provide one, two, or all of these services. Navigation systems can be further distinquished by how they provide the information:

Verbal systems speak.

Textual systems provide text.

Graphic systems provide pictures.

Finally, systems can be classified as either real time or static. The categories of this classification are not independent. There can be no static positioning system, since one cannot predict the future position of an automobile.

There are several problems with static navigation systems. First, they do not help the driver follow the route. The driver must determine when to apply each instruction. A second problem is that since the instructions must be specified in advance, there is little to be done if the driver does not follow the instructions, which might happen from error, or because the instructions are wrong, or simply ill-advised (as when confronting a traffic jam).

Previous automobile navigation systems have used text or graphics to give navigation information. However, there are several disadvantages to presenting information visually. First, the driver must look at a display while driving, which makes driving less safe. For providing driving directions, visual displays are most easily used when they are least needed. Second, with respect to graphic displays, many people have difficulty using maps, making this mode of providing information undesirable. However, if speech is used, the driver's eyes are left free for driving. In addition, speech uses words, and can therefore refer to past and future actions and objects not yet seen. This is hard to do with symbolic displays or maps.

There is clearly a need for an instructional, verbal, real time automobile navigation system which can guide a driver to a destination much as a passanger familiar with the route would. The present invention meets that need.

SUMMARY OF THE INVENTION

The present invention, called the "Back Seat Driver", is a computer navigation system which gives spoken instructions to the driver of an automobile to guide the driver to a desired destination. Computing apparatus, installed either in the automobile or accessed through a cellular car phone, contains a map database and a route finding algorithm. A vehicle location system uses data from a position sensor installed in the automobile to track the location of the automobile. Discourse generating programs compose driving instructions and other messages which are communicated to the driver using voice generating apparatus as the driver proceeds along the route.

The important differences between The Back Seat Driver and other such systems are that the Back Seat Driver finds routes for the driver, instead of simply displaying position on a map, tells the driver how to follow the route, step by step, instead of just showing the route, and speaks its instructions, instead of displaying them. Each of these design goals has required new features in the programs or in the street map database.

The street map database of the Back Seat Driver distinguishes between physical connectivity (how pieces of pavement connect) and legal connectivity (whether one can legally drive onto a physically connected piece of pavement). Legal connectivity is essential for route finding, and physical connectivity for describing the route.

To find the fastest routes, the map database of the Back Seat Driver includes features that affect speed of travel, including street quality, speed limit, traffic lights and stop signs. To generate directions, the map includes landmarks such as traffic lights and buildings, and additional descriptive information about the street segments, including street type, number of lanes, turn restrictions, street quality, and speed limit. The map also preferably includes other features, such as time-dependent legal connectivity, and expected rate of travel along streets and across intersections. Positions are preferably stored in the map database in three dimensions, not two, with sufficient accuracy that the headings of the streets can be accurately determined from the map segments.

Driving instructions generated by the Back Seat Driver are modeled after those given by people. The two issues for spoken directions are what to say (content) and when to say it (timing). The content of the instructions tells the driver what to do and where to do it. The Back Seat Driver has a large taxonomy of intersection types, and chooses verbs to indicate the kind of intersection and the way of moving through it. The instructions refer to landmarks and timing to tell the driver when to act.

Timing is critical because speech is transient. The Back Seat Driver gives instructions just in time for the driver to take the required action, and thus the driver need not remember the instruction or exert effort looking for the place to act. The Back Seat Driver also gives instructions in advance, if time allows, and the driver may request additional instructions at any time. If the driver makes a mistake, the Back Seat Driver describes the mistake, without casting blame, then finds a new route from the current location.

Giving instructions for following a route requires breaking the route down into a sequence of driving acts, and knowing when an act is obvious to the driver and when it needs to be mentioned. This further requires knowledge about the individual driver, for what is obvious to one may no be so to another. The Back Seat Driver preferably stores knowledge of its users, and uses this knowledge to customize its instructions to the preferences of the users.

Speech, especially synthetic speech, as an output media imposes constraints on the interface. The transient nature of speech requires that utterances be repeatable on demand. The Back Seat Driver has the ability to construct a new utterance with the same intent, but not necessarily the same words, as a previous message.

Synthetic speech being sometimes hard to understand, the Back Seat Driver chooses its words to provide redundancy in its utteranaces.

An actual working prototype of the Back Seat Driver has been implemented. It has successfully guided drivers unfamiliar with Cambridge, Mass. to their destinations. It is easy to foresee a practical implementation in the future.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates schematically the basic functional components of the Back Seat Driver in its preferred embodiment.

FIG. 2 illustrates the system processes of the preferred embodiment of the Back Seat Driver.

FIG. 3 is a schematic illustration of the map database.

FIG. 4 is a schematic illustration of the route finder.

FIG. 5 is a schematic illustration of the position sensor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The automobile navigation system according to the present invention is illustrated schematically in FIG. 1. The heart of the system is a computing apparatus 10 comprising a vehicle location system 12, a map database 14, a route finder 16, a discourse generator 18, and a speech generator 20. Driver input means 22 allows the driver to input to the computing apparatus 10 information such as a desired destination. A position sensor 24 measures automobile movement (magnitude and direction) and sends data to the location system 12 which tracks the position of the automobile on the map. The route finder 16 calculates a route to the destination. Based on the current position of the automobile and the route, the discourse generator 18 composes driving instructions and other messages according to a discourse model in real time as they are needed. The instructions and messages are sent to the speech generator 20 which conveys them to the driver by means of a speaker system 26. The speaker system may be that of the car's radio.

In FIG. 1, the computing apparatus is illustrated as a single entity. However, in other embodiments, the components may not all be implemented in the same piece of apparatus. For example, in one working prototype of the Back Seat Driver, the main computing apparatus is a Symbolics Lisp machine, but the location system is implemented separately by an NEC location system that tracks the position of the automobile using its own map database, and the speech generator is implemented separately by a Dectalk speech synthesizer. In another working prototype, the main computing apparatus is a Sun Sparc workstation. The map database for the Back Seat Driver can be provided on a CD-ROM, a floppy disk, or stored in solid-state memory, for example.

The components of the system and the system processes which coordinate their performance, particularly as embodied in the working prototypes, are discussed in the sections which follow. Aspects of the invention are also described in the following sources, which are hereby incorporated by reference:

1. "Synthetic speech for real time direction-giving," by C. M. Schmandt and J. R. Davis, *Digest of Technical Papers, International Conference on Consumer Electronics*, Rosemont, Ill., Jun. 6–9, 1989.
2. "Synthetic speech for real time direction-giving," by C. M. Schmandt and J. R. Davis, *IEEE Transactions on Consumer Electronics*, 35(3): 649–653, August 1989.
3. "The Back Seat Driver: Real time spoken driving instructions," by J. R. Davis and C. M. Schmandt, *Proceedings of the IEEE Vehicle Navigation and Information Systems Conference*, Toronto, Canada, September 1989.
4. "Back Seat Driver: Voice assisted automobile navigation," by J. R. Davis, Ph.D. thesis, Massachusetts Institute of Technology, September 1989.

MAP DATABASE

The map database for the Back Seat Driver in the working prototypes originated as a DIME (Dual Indepedent Map Encoding) file, a map format invented by the U.S. Census Bureau for the 1980 census. Implementing the Back Seat Driver required extending the DIME map format in a number of ways to make it useful for route finding and route describing.

The basic unit of the DIME file is the segment. A segment is a portion of a street (or other linear feature such as a railroad, property line, or shoreline) chosen to be small enough that it is a straight line and has no intersection with any other segment except at its endpoints.

The two endpoints of a segment are designated FROM and TO. If the segment is a street segment (as opposed to, say, a railroad) and has addresses on it, then the FROM endpoint is the one with the lowest address. Otherwise, the endpoint labels are chosen arbitrarily. A segment has two sides, left and right. The sides are chosen with respect to travel from the FROM endpoint to the TO endpoint. A navigator using a DIME file can find the location of an address along the segment by interpolating the addresses between the low and high addresses for the two endpoints. The DIME file is suited to determining the approximate position of a building from its street address.

Attributes of a DIME file segment include: its name (40 characters), its type (a one to four character abbreviation such as "ST"), the ZIP code for each side, and the addresses for each endpoint and each side. At each endpoint of a segment is a pointer to a node. A node represents the coordinates of that endpoint and the set of other segments which are physically connected at that endpoint. Segments share nodes. If any two segments have an endpoint at the same coordinate, they will both use the same node for that endpoint.

A vehicle navigation system using a DIME file can represent the position of a vehicle on the map by a structure called a position. A position has three parts: a segment, an orientation, and a distance. The segment is one of the segments from the map database, the orientation specifies the direction the vehicle is travelling (towards the TO or FROM endpoint), and the distance is the distance from the FROM endpoint of the segment, no matter which way the vehicle is oriented. When travelling towards the TO endpoint of the segment, distance increases, when travelling towards the FROM endpoint, it decreases.

The DIME file is not adequate for routing finding and is only marginal for generating route descriptions. The most important problem with the DIME format is that it indicates only if two segments are physically connected (that is, if they touch), but not whether they are legally connected (i.e. whether it is legal to travel from one to the other). Legal connectivity is crucial for route finding. However, legal connectivity does not

replace physical connectivity; route description requires information about physical connections as well. Physical connectivity also affects route finding directly when seeking the simplest route, since ease of description is determined in part by physical connectivity.

The most significant extension of the DIME file format required for its use in a vehicle navigation system is the explicit representation of legal connectivity. This can be accomplished by adding a legal connection list at each endpoint of a segment to indicate all segments which are legally accessible from that endpoint. This allows the route finder to consider only legal paths. To the inventor's knowledge, this has not been included in any other navigation system.

Another problem with the DIME file is that it is a planar graph. This means that no two segments can cross except at an intersection, so there is no way to correctly represent an overpass, for example. The DIME format represents an overpass by breaking both streets at the point where they cross, and creating a fictitious intersection even though the segments do not touch in reality. These false intersections are particularly troublesome since DIME does not represent legal connectivity, so it appears possbile and legal for a car to jump straight up and turn onto the overpass.

Points in the map database for a vehicle navigation system are therefore preferably three-dimensional. Route descriptions then provide better knowledge of the underlying topography. Stopping distance is affected by slope, so instructions must be given sooner when traveling down a hill. Slope affects safety. The route finder should avoid steep slopes in snowy weather. Finally, distance between points will be more accurate when change in altitude is considered. Roads designed for high speed may be more level than the underlying topography. They may be elevated or they may be depressed. A road which is not at grade will not have the slope of the land beneath it.

Coordinates in the DIME file are stored in ten thousandths of a degree. This means that the position of an endpoint in the map differs form the true position by as much as 6.5 meters in latitude and 5 meters in longitude at the latitude of Boston. This inherent position error causes problems because it introduces error in length and in heading. Uncertainty in heading causes uncertainty in the angle between two segments. A straight street can appear to wobble if it is made of many short segments. Segment "wobble" causes problems for a route finder, makes it hard to generate correct descriptions, and interferes with position determination.

DIME file segment "wobble" can be corrected for by assuming that the angle between two streets is the smallest possible value. However, this sometimes overestimates the speed an intersection can be travelled through. Uncertainty in the angle of segments at an intersection also makes it difficult to describe the intersection correctly and interferes with navigation because it makes it difficult to compare compass headings with the heading of a street.

A richer taxonomy of street types than that provided by DIME is preferable for a vehicle navigation system. Important categories of streets are: ordinary street, rotary, access ramp, underpass, tunnel, and bridge. Preferably, non-streets such as railroad, water, alley and walkway are also included.

The DIME file records a small amount of information about each segment. For a vehicle navigation system, additional attributes are preferably added to make better descriptions. Important additional attributes are street quality, divided roads, signs, traffic lights, stop signs, buildings, other landmarks, lane information, and speed limit.

The street quality can be, for example, a number from 1 ("super") to 4 ("bad") which combines the ease of locating and following the street and the expected rate of travel along it. The street quality attribute should be used by both the route finder and the route describer.

The identification of divided roads is necessary to avoid U Turns where they are not possible, although it is preferable to make U Turns only if there is no other alternative. In addition, the route finder should recognize that a divided road is safer than an undivided road.

Sign and exit numbers are preferably stored in the map database as connection cues, which are text strings that give cues for moving from one segment to another. Every cue has a type which tells the kind of cue, e.g. sign or exit-number. There may be more than one connection cue for a given pair of segments, but there should never be more than one of a type.

The most useful landmarks are traffic lights. Traffic lights are preferably stored independently for each endpoint of each segment, since the presence of a light at one segment of an intersection does not imply that all other segments at the intersection have a light.

Two types of buildings which are especially useful as landmarks are toll booths and gas stations. Toll booths can be stored as connection cues. Gas stations can be stored in the services database described below. However, a preferred approach is to index gas stations (and other buildings) by street.

Roads often have more than one lane. Selecting the proper lane can make travel faster, and it may even be mandatory, since certain turns may only be possible from some lanes. The map database therefore preferably contains the number of lanes for both directions on a segment, and whether one or more lanes is reserved for turn restrictions.

The map database also preferably includes time dependent legal connectivity. Sometimes a given turn will be prohibited at certain hours of the day, typically rush hour. Additionally, lanes sometimes switch direction during the day to accomodate rush hour traffic, and some lanes are reserved for carpools during rush hour.

The expected rate of travel is not necessarily a function of street quality. Although there is a correlation, travel rate is preferably a separate segment attribute. One reason is that travel rate, unlike quality, changes during the day. A model of traffic flow like that of an experienced driver (i.e. it should know what "rush hour" means) is preferably implemented in the map database.

Some turns, though legal, are difficult to make. The route finder preferably avoids these turns if possible. To an extent, the difficulty of a turn is implicit in the quality of the participating street segments, but an explicit model in the map database is preferred.

Some lanes or streets are restricted to certain kinds of traffic (car pools, no commerical vehicles). Also important are height restrictions, since some underpasses are so low that tall vehicles will not fit under them. This information is preferably included in the map database.

At some lights it is permitted to make a right turn at a red light after a full stop. Right turns here will be no slower than rights turns at a stop sign, so the route finder should prefer such intersections to those that do not permit it. Also, traffic lights have differing cycle

lengths. The map database preferably includes this information.

Local knowledge is also preferably included in the map database. These are facts about how people and institutions act on or near the road; e.g. that a speed trap is here, or that this road is one of the first ones plowed after a snow storm.

The Back Seat Driver should allow the driver to select famous destinations by name in addition to address by including this information in a database, and this database should be integrated with the services database, discussed below. The Back Seat Driver should also support names of buildings and office plazas made up by developers without reference to the street names.

Service locations are preferably stored in a services database. This database lists services such as gas stations, automatic teller machines and stores. For each service is recorded the name of the establishment, the address, phone number, and hours of operation. This allows the Back Seat Driver to select the closest provider of a service known to be open. The database can also be used as a source of landmarks when giving directions.

The map database preferably contains information on the division of the city into neighborhoods. This is useful for selecting an address. The postal ZIP code is not good for classifying neighborhoods.

Pronunciation information is preferably stored in a database for those place names which are easily mispronounced by the speech synthesizer. It would also be desirable to record which of those names have unusual spellings. This would allow the system to warn the driver to be alert for signs that might otherwise surprise her. Note that the driver only hears the name of a street and has to guess how it is spelled from the sound she hears.

Abbreviations are preferably included to allow the user to enter certain street names in abbreviated form. A second use for abbreviations is to supply alternate spellings for streets, for example, to allow the driver to spell "Mt Auburn" as "Mount Auburn".

An almanac is preferably included to list the time of sunrise and sunset for the city. Arrangements can be made to either purchase this database or locate a program which an calculate it, for arbitrary position and date.

A problem for a practical Back Seat Driver is how to keep the map database accurate, since the streets network is constantly changing. Over time, new street are constructed, old streets are renamed or closed. These kinds of changes are predictable, slow, and long lasting. Other changes are unpredictable, quick, and transient. A road may be closed for repairs for the day, blocked by a fallen tree, or full of snow. Such changes are usually short lived. Thus, the Back Seat Driver needs the ability to change legal connectivity dynamically. In addition, the route finder should preferably have the ability to avoid congested roads caused by rush hour or accidents, for example. The map database is therefore preferably continuously updated by some form of radio broadcast by an agency that monitors construction and real time traffic conditions.

The Census Bureau, in cooperation with the United States Geological Survey, has designed a new map format known as TIGER (Topologically Integrated Geographic Encoding and Referencing) which has several improvements over the DIME format, but which is still a planar graph representing only physical connectivity. The map database for a Back Seat Driver could be also be originated from a TIGER file as long as the extensions discussed above were implemented.

The map database is shown schematically in FIG. 3. In the preferred embodiment, the map database 14 includes, as its basis, a file 28 of segments and nodes. File 28 may be an original file or may be adapted from a DIME file or a TIGER file by adding the above-described extensions. In addition, the map database 14 may include optional features 30, as described above.

ROUTE FINDER

Finding a route between two points in a street network is an example of searching a general graph. The task is to find a sequence of segments that lead from the origin to the destination. There are usually a great many distinct ways of getting from one place in the city to another, some better than others. Graph search algorithms differ in the quality of the solution they find and the time they require. The Back Seat Driver requires an algorithm that finds a good route in a short time.

The route finder of the working prototypes of the Back Seat Driver is based on an A* search algorithm. The A* algorithm is a form of best-first search, which itself is a form of breadth-first search. These searching techniques are well-known and are described in detail in Davis, 1989, cited above.

In a breadth-first search, a tree of all possible decisions is divided into levels, where the first level actions are those leading from the root, the second level actions are those that come from situations after first level actions, and so on. All actions at a given level are considered before any at the next higher level. While the breadth-first search is operating, it maintains a list of all possible partial routes and systematically examines every possible path from the end of every partial route to compile a new list of partial routes. This search procedure finds the path with the fewest segments. However, this is not necessarily the best path. To be sure of finding the best path, the search cannot stop when the first path is found, but must continue, expanding each path, until all paths are complete. This is not at all desirable, since there could be (and in fact will be) many paths.

The best-first algorithm solves this problem by keeping track of the (partial) cost of each path, and examining the one with the smallest cost so far. This requires a function that can compare two routes and produce a numeric rating. Such a function is called a metric. To further reduce the cost of searching, before adding a segment to a path, the best-first search checks to see whether it is a member of any other path. If it is, it is not added, for presence on the other path means that the other path was a less expensive way of reaching the same segment.

Best-first search finds the best solution and requires less time than exhaustive breadth-first search, but it still must consider partial solutions with an initial low cost which prove expensive when complete. The A* algorithm avoids wasting time on such falsely promising solutions by including an estimate for the completed cost when selecting the next partial solution to work on. The cost estimate function is $f^*(r)=g^*(r)+h^*(r)$, where r is a route, $g^*(r)$ is the known cost of the partial route, and $h^*(r)$ is the estimate of the cost to go from the endpoint of the route to the goal. The h^* function must have the property of being always non-negative and

never over-estimating the remaining cost. An h* meeting these two conditions is said to be admissible. It should be obvious that if h* is chosen to be always zero, then A* search is just best-first search. In applying A* to finding routes on a map, h* is just the cartesian distance between the endpoint of the partial route and the destination point. It is certain that no route will be shorter than the straight line, so this estimate is never an over estimate. A* search is more efficient than best-first.

The A* algorithm finds the optimum route, but the Back Seat Driver might be better served with an algorithm that finds a reasonable route in less time. This is especially true when the vehicle is in motion. The longer the route finder takes, the greater the distance that must be reserved for route finding. As this distance becomes larger, it becomes harder to predict the future position of the car. This can be done by choosing an h* which multiplies the estimated distance remaining by a constant D. Setting D greater than one makes h* no longer admissible, since the estimate might exceed the actual cost by a factor of D. The resulting routes are no longer optimal, but are still pretty good. The effect is to make the algorithm reluctant to consider routes which initially lead away from the goal.

The route finder preferably uses a value of 2 for D. This yields the greatest increase in payoff. A possible improvement is to run the route finder twice, first with a high value of D to find an initial route in order to begin the trip, and then with a low D to search for a better route, using spare time while driving.

Preferably, three different metrics are used. The distance metric finds the shortest route, the speed metric finds the fastest route, and the ease metric finds the easiest route. The metric for distance is just the sum of the lengths of the component segments. The other two metrics are more complicated than the distance metric, because they must consider intersections as well as segments. In general there is a cost to travel along a segment and a cost to get from one segment to another. All costs are expressed as an "equivalent distance" which is the extra distance one would travel to avoid the cost.

The metric for speed estimates the cost for traveling along a segment by multiplying its length by a constant which depends upon the quality of the street. In principle, one could calculate expected time by dividing length by the average speed on the segment were this quantity available in the database. Examples of appropriate constants are:

Quality	Factor
super	1
good	1.2
average	1.5
bad	2.0

All multiplicative constants must be greater than or equal to one to ensure that the cost of a route is never less than the straight line distance between two points. This condition is essential for the correct operation of the A* search algorithm, since the estimation function (g*) must always return an under-estimate.

The time to cross an intersection is preferably modeled by a mileage penalty which depends upon the nature of the intersection. Examples of appropriate penalties are:

Factor	Cost	Reason
turn	[illegible] mile	Must slow down to turn
left turn	[illegible] mile	May have to wait for turn across traffic flow
traffic light	[illegible] mile	Might be red

If the segment is one-way, the penalties should be cut in half, since there will be no opposing traffic flow. The turning penalties should be computed based only on the angle between two segments, not on the segment type or quality.

The metric for ease seeks to minimize the driver's effort in following the route. Again, driver's effort is the sum of the effort to travel along a segment and the effort to get from one segment to another. Travel along a segment depends upon its quality. Turns of every sort should be penalized equally, since they all require decisions. The intention of this metric is to find routes which require the least amount of speaking by the Back Seat Driver, leaving the driver free to concentrate on other matters.

If the driver leaves the route, the Back Seat Driver must immediately inform the driver and begin to plan a new route. Route planning after a mistake is no different from any other time, except that the vehicle is more likely to be moving. In the working prototypes, when the car is moving, the Back Seat Driver first estimates the distance the car will travel during the route finding process by multiplying the current velocity by the estimated time to find the route. Then it finds the position the driver will reach after traveling this distance, assuming that the driver will not make any turns without being told to do so. It then finds a route from this extrapolated position to the goal. Finally, it finds a route from the car's actual position to the estimated starting position. This second route is so short that the car is unlikely to move far during the time it is computed.

The route finder of the working prototypes estimates the time to find the route between two points by multiplying the distance between them by a constant. This constant was initially determined by running the route finder for 20 randomly selected pairs of origins and destinations. As the Back Seat Driver runs, it accumulates additional values for the constant.

A problem is how to reliably detect when the driver has left the route. With the extended DIME format of the working prototypes, if the driver turns into a gas station, for example, the system will believe, falsely, that the driver has turned onto some street, because the street map includes only streets, and not other paved areas such as parking lots and filling stations. From this false belief, the system will conclude that the driver has made a mistake. However, this problem can be solved by increasing the detail of the map.

Sometimes the driver will choose to not follow a route for good reasons that the Back Seat Driver is unaware of, perhaps because the road is blocked or because of a traffic jam. For the first case, the driver should be provided an "I Can't Do It" button or other means to inform the Back Seat Driver that the road is (temporarily) blocked. Once informed, the Back Seat Driver must automatically find a new route. For the second case, the driver's only recourse is to cancel the current trip (by pushing another button, for example), and, once out of the situation, re-request a route to the original destination. It is essential, though, that the

driver either notify the Back Seat Driver of the impossibility of the requested action or cancel the trip, because otherwise the Back Seat Driver will treat the deviation from the route as a mistake, and continue to attempt to find a new route, which may very well lead back through the street the driver is trying to avoid.

The route finder is shown schematically in FIG. 4. In the preferred embodiment, the route finder 16 includes, as its basis, an algorithm 32. Algorithm 32 may be, for example, an original algorithm based on a best-first search algorithm the A* algorithm, or a modified A* algorithm. In preferred embodiments, the route finder is adapted to find the best route according to any one of three cost metrics 34: distance, speed, simplicity. The route finder calculates a new route in the event of driver error or unforeseen circumstances, as indicated.

LOCATION SYSTEM AND POSITION SENSOR

The Back Seat Driver must know the position of the vehicle. This can be achieved using available technology adapted for the requirements of the Back Seat Driver. At a minimum, the location system for a vehicle navigation system must determine the vehicle position to the nearest block. If it is to tell the driver when to turn, it must be able to distinguish between the closest of two adjacent turns.

Consideration of the Boston street map shows that it has many streets which are both short and a possible choice point. Based on a study of the percentage of segments which are shorter than a given length, an accuracy of 10 meters is desirable. This is a higher accuracy than has been specified in prior art approaches (see Davis, 1989, cited above). The Back Seat Driver's use of speech imposes strict requirements on position because of limitations on time. Unlike a display, speech is transient. An action described too soon may be forgotten. The Back Seat Driver is intended to speak at the latest time that still permits the driver to act. Allowing two seconds for speech, a car at 30 mph covers 27 meters. This consideration suggests a minimum accuracy of 15 meters.

Location systems can be divided into two categories:

Position finding systems determine position directly by detecting an external signal.

Position keeping (dead reckoning) systems estimate the current position from knowledge of an earlier position and the change in position since that position.

All existing position finding systems use radio signals. The broadcast stations may be located on street corners, seacoasts, or in orbit around the earth. Systems differ in their range, accuracy, and cost. A survey of those systems which might plausibly be used for automobile navigation is included in Davis, 1989, cited above.

Position keeping (dead reckoning) systems obtain position indirectly, by keeping track of the displacement from an originally known position. One can measure displacement directly, or measure velocity or acceleration and integrate over time to obtain displacement.

The forward motion of a car is measured by the odometer. On late model cars, the odometer cable has been standardized. It revolves once every 1.56 meters. This is a reliable measure of forward progress, as long as the wheels do not slip. Measuring direction, though, is more difficult. Among the possibilities are:

magnetic compass A magnetic compass has the advantages of small size and ease of use, but is unreliable because of variation between magnetic and true north and deviation due to the ferrous material of the car and magnetic flux arising from electric currents within the car.

steering wheel The steering wheel could be instrumented to measure the amount of turning.

differential odometer When a car turns, the two rear wheels travel different distances, and thus rotate at different rates. Measuring the difference in rotation provides an indication of amount of turning. This differential rate of rotation is just what is measured by anti-skid brakes, so no additional instrumentation is required to obtain this measure for an automobile suitably equiped.

gyroscope Gyroscopes measure angular acceleration. The familiar rotation gyroscope and esoteric laser ring gyroscope are not suitable for automotive use because they are too expensive. Lower cost alternatives are the rate gyro and the gas jet gyro. The rate gyro measures angular acceleration in a vibrating piezo-electric substance. The gas gyro measures turn (or yaw) rate. In this design, a jet of gas travels down the center of a sealed tube. Anemometers are placed on either side of stream. When the car turns, the stream is deflected and the velocity is measured. The velocity of the gas at the anemometer is proportional to the turn rate. Such devices can measure turn rates of up to 100 degrees per second, with a noise of about one half degree/second.

The position sensor is shown schematically in FIG. 5. As indicated, it includes a displacement sensor 36 and a direction sensor 38.

A position keeping system with no error could be calibrated when installed, and then maintain its own position indefinitely. Unfortunately, errors arise in measuring both distance and heading. Sources for error include difference in tire pressure, composition and wear, slipping, cross steering from winds, change in tire contact path in turns, magnetic anomalies, and gyro noise. The NEC dead reckoning system, employed in the prototypes of the Back Seat Driver, accumulates about one meter of error for every ten meters traveled. The error is even worse when traveling near railroads because the NEC system uses a magnetic compass.

Some dead reckoning systems recalibrate themselves to eliminate systematic errors. Such recalibration is possible when the vehicle is at a known position or when stopped. One way to correct dead reckoning errors is to use knowledge of the road network as a constraint on position, in what is known as map matching. Map matching requires that the position keeping system have a map of the locale where the vehicle is being driven, and is based on the assumption that the vehicle is always on a street present in the map. If the estimated position falls to one side of the road, the estimate can be corrected. When the vehicle makes a turn, the system assumes the vehicle is at the closest intersection, and thus the absolute position can be estimated. Every dead reckoning system uses some form of map matching. Map matching reduces the stringency of position keeping, but accuracy remains a concern, since the system must maintain its position when the driver drives off the map, e.g. into a driveway or a parking lot.

In the working prototypes, a unit built by NEC Home Electronics, Ltd. is employed. It is a dead-reckoning position keeping system which uses speed and direction sensors. To compensate for error, it uses map matching on a map database stored on CD-ROM. The unit is described in "CD-ROM Assisted Navigation

Systems" by O. Ono, H. Ooe, and M. Sakamoto, in *Digest of Technical Papers, IEEE International Conference on Consumer Electronics*, Rosemont, Ill., Jun. 8–10, 1988.

As implemented in the working prototypes, the map database used by the location system is completely distinct from the map database used by the route finder and discourse generator. This is unfortunate since the maps will not always agree unless they are kept equally up-to-date. However, in other embodiments within the scope of the invention, the location system uses the computing resources and map database of the main computing apparatus illustrated in FIG. 1. Positioning systems for the Back Seat Driver preferably combine position keeping and position finding, since neither alone will work all the time. A position keeping system needs periodic corrections, but a position finding system that depends on radio reception will not work in tunnels or bridges. Hybrid systems which could be used by the Back Seat Driver are referenced and discussed in Davis, 1989, cited above.

DISCOURSE GENERATOR

The Back Seat Driver attempts to provide instructions to the driver as a passenger in the car familiar with the route would. The content and timing of the instructions and other messages described below are based on a study of natural driving instruction described in detail in Davis, 1989, cited above.

To the Back Seat Driver, a route is a sequence of street segments leading from the origin to the destination. Each connection from one segment to another is considered an intersection, even if there is only one next segment at the intersection. At any moment, the car will be on one of the segments of the route, approaching an intersection. The task of the Back Seat Driver is to say whatever is necessary to get the driver to go from the current segment, across the intersection, to the next segment of the route. Most often, nothing need be said. But at other times, the Back Seat Driver will need to give an instruction.

Instructions must use terms familiar to the driver. An example is what to say at a fork in the road. Considering only topology, there is no difference between a fork and a turn, but it would be confusing to call a fork a turn.

The two key issues in describing a route are deciding what to say and deciding when to say it. There is a tradeoff between these two factors. At one extreme are directions given completely in advance, with no control over when the driver reads them. A direction of this kind might be: "Go half a mile, then take a left onto Mulberry Street". A driver following such an instruction must use the odometer to estimate distance or look for a street sign. The instruction itself does not say when to act. The other extreme are instructions which rely totally on timing for success. Such an instruction might be: "Turn left now".

An intersection type is called an act because the important thing about an intersection is what action the driver takes to get across it. The Back Seat Driver is preferably implemented with an object-oriented programming methodology, so for each act there is an expert (an object) capable of recognizing and describing the act. The Back Seat Driver generates speech by consulting these experts. At any moment, there will be exactly one expert in charge of telling the driver what to do. To select this expert, the Back Seat Driver asks each expert in turn to decide whether it applies to the intersection. The experts are consulted in a fixed order, the most specific ones first. The first expert to claim responsibility is selected. This expert then has the responsibility of deciding what (if anything) to say.

Each act has a recognition predicate which is used to determine if a given intersection should be classified as that act. A predicate can consider topology, geometry, the types of street involved, or any other factor. The predicate also decides whether the move is obvious, that is, the driver can be trusted to do it without being explicitly told to do so. Actions that are obvious are not described. If the next action is obvious, the Back Seat Driver looks ahead along the route until it finds one which is not obvious. There will always be at least one, because stopping at the end is never obvious.

The acts in the working prototypes include CONTINUE, FORCED-TURN, U-TURN, ENTER, EXIT, ONTO-ROTARY, EXIT-ROTARY, STAY-ON-ROTARY, FORK, TURN and STOP.

A CONTINUE is recognized when the driver is to stay on the "same" road. Almost always, a continue is obvious and nothing should be said. The continuation of a street depends on the type of street: from a rotary, it is the next rotary segment; from an access ramp, if there is exactly one next segment, that is the continuation, otherwise there is no obvious next segment; otherwise, it is the one segment that requires no more than 30 degrees of angle change (if there is exactly one, and if it is not a rotary) or the one segment with the same name (if there is exactly one). The reason for comparing names is not because the driver is aware of the name, but because the designer who named the street was. The assumption is that if two segments have the same name, they are the same street, and that is why they have the same name. This "sameness" is presumably reflected in details not captured by the map, for example continuity of painted centerline. There are many places in the area where the obvious "straight" continuation of a segment is at an angle as great as 45 degrees, but it would not be right to call this a turn.

A FORCED-TURN is an intersection where there is only one next street segment where the road bends more than 10 degrees. Even though there is no decision to make at a forced turn, it is useful to mention because it strengthens the driver's sense that the Back Seat Driver really knows about the road conditions. A forced turn is not worth mentioning if both segments are part of a bridge, a tunnel, or an access ramp, or if the angle is less than 20 degrees.

The U-TURN action is recognized when the heading of the car is the opposite of what it should be. Recall that a route is a sequence of segments and endpoints. At all times the car will be on one of the segments in the sequence. If the car's orientation is not the same as the endpoint in the path, then the driver must turn around. Preferably, the route finder only calls for a U Turn if there is no other way.

To ENTER is to move onto a super street (or an access ramp that leads eventually to a super street) from an ordinary street, but not from a super street or an earlier access ramp. Similarly, to EXIT is to move from a super street onto a street with lesser quality that is either an access ramp or has a different name. Some super streets are not uniformly super and it would not be right to call the change in quality an exit.

To go ONTO-ROTARY, to STAY-ON-ROTARY, and to EXIT-ROTARY are acts which can be correctly

described only if the street map database includes an explicit marking of streets as rotaries.

At a FORK, there must be at least two alternatives, all within a narrow angle, and none of the branches must be the obvious next segment—that is, the branches must all be more or less equal. Either all the alternatives must be access ramps, or none of them must be. A branch can only be considered obvious if it is the only branch with the same level of quality, or if it is markedly straighter than the others, or if it is the only one with the same number of lanes, provided that all of these clues agree. If one branch is stronger than the others, the intersection is not a fork. It is either a continue or a turn.

The STOP action is recognized when the vehicle is on the destination segment. Finally, a TURN is an intersection not handled by one of the above cases. The greatest weakness of the above approach is that the recognition predicates are sensitive to small changes in the angles between segments. It is not likely that people use absolute numbers (e.g. 10 degrees) as cut-off values for their determination of how to describe an intersection. More likely, different classifications compete. Still more important, people making classifications use visual cues, not just facts from the map.

Each act has a description function to generate a description of the action. The description function takes inputs specifying the size of the description (brief or long), the tense (past, present or future), and the reference position. A short description is the minimum necessary for the act. It is typically an imperative (e.g. "Bear left."). A long description includes other facts about the action, an expression indicating the distance or time until the act is to be performed, and possibly information about the next act, if it is close. The reference position is a position (along the route) from which the action is to be described.

A brief description consists only of a verb phrase. The verb depends on the type of act and perhaps on the specifics of the act. Besides the verb itself, the verb phrase must say which way to go. In most cases, the word "left" or "right" is sufficient. Where it is not, the possibilities are to use a landmark or to describe the turn. A landmark can be either in the appropriate direction ("towards the underpass") or the other direction ("away from the river"). Specifying direction with a landmark has the advantage that some drivers confuse left and right sides, or mishear the words, so it is a redundant cue. Also, it increases the driver's confidence that the system really knows what the land looks like. A description of the turn can mention either quality or the relative angle of the desired road. The angle must be described qualitatively (more or less "sharp"). It would be more precise to use the angular distance (e.g. "turn right 83 degrees"), but drivers would not understand it.

Preferably, the expert for each act follows a protocol which includes:

recognize?—is a proposed movement an example of this kind of driving act?

instruction-vp—generate a verb phrase describing this act

instruction-np—generate a noun phrase describing the act

position-to-doit—the position where the driver would begin carrying out the act

obvious?—would the driver do this act without being told?

sentences—generate all sentences needed to describe this act

congratulate?—should the driver be congratulated after carrying out this kind of act

The following sample is a Back Seat Driver description of the left turn from Fulkerson Street to Main Street in Kendall Square, Cambridge, Mass.:

> Get in the left lane because you're going to take a left at the next set of lights. It's a complicated intersection because there are two streets on the left. You want the sharper of the two. It's also the better of them. After the turn, get into the right lane.

This instruction begins with a piece of lane advice, an action to be taken immediately, then describes an action in the near future. The action is a turn, though that word is not used explicitly. It tells the direction of the turn (left) and specifies a landmark (the lights) that says where the turn is. In many cases, this would be enough, but here there are two streets on the left, so the instruction goes on to specify the desired road in two ways (by comparative position and relative quality). Finally, it concludes with some lane advice to be executed during (or just after) the act.

The above example is the most complicated text that the Back Seat Driver prototypes have produced. Length and detail are not virtues in giving directions. The Back Seat Driver produces a text this long only because it does not have better means to make the driver follow the route. If a shorter text would accomplish the same aim, it would be better.

Besides telling drivers what to do, the Back Seat Driver must also tell them when to do it. One way to do this is by speaking at the moment to act, but it is useful to also give instructions before the act, if time permits. This allows time for preparation, if required, permits the driver to hear the instruction twice, and also spares the driver the need to be constantly alert for a command which must be obeyed at once.

When an act is more than a few seconds in the future, The Back Seat Driver uses a long description, which includes one or more cues which either describe the place for the act, the features of the road between the current location and the place, or the distance or time until the act. This description should be so clear that the driver cannot only recognize the place when it comes, but can also be confident in advance that she will be able to recognize the place.

The Back Seat Driver preferably uses a landmark as a cue when it can. A numeric distance is the cue of last resort. However, some drivers prefer to also hear distances, especially if the distance exceeds a certain threshold. Therefore, a parameter is preferably included in the user-model, described below, for this minimum distance expressed as a number. If the distance is below this, a qualitative phrase is produced by the discourse generator, if above, a number is produced. The cutoff can be zero, in which case numbers are always used, or set to an infinite value, in which case they never are.

A cue is expressed either as a full sentence ("Drive to the end of the street, then . . . ") or a preposed preposition phrase ("At the next set of lights, . . . "). Research has shown that a cue should not be expressed by a preposition after the verb as in "Take a left at the lights." because some drivers start to take the left as soon as they hear the word "left". This may be because syn-

thetic speech does not provide enough intonational cues for the driver to reliably predict the length of the sentence, leading the driver to act on syntactic information alone, and thus taking the sentence to be complete as soon as the word "left" is heard.

The description of a road feature depends upon whether or not it is visible. If it is, it can be referred to with a definite article ("the rotary", "the overpass"). If not, an indefinite article is used. The program cannot tell whether an entity is actually visible, so it uses distance as an approximation. If the feature is closer than one tenth of a mile, it is considered to be visible.

A special case of cues is when the driver is at the place to act. When stopped a few meters from the intersection, it is wrong to say "Turn at the next lights" even if it is literally true. In the working prototypes, the Back Seat Driver thinks of itself as being at that intersection it if its less than thirty yards away, except that if there is a stop light at the intersection and the car is not moving, then the intersection distance if fifty yards, since cars might be backed up at such an intersection. When at an intersection, the Back Seat Driver should say "Take a left here" rather than "Take a left now" because drivers waiting for a traffic light will rightly resent being told to do something they have good reason not to do.

Traffic lights are very good landmarks because they are designed to be easily seen and drivers have an independent reason to watch for them, namely a desire to avoid accidents. When referring to a traffic light, if the car is at the intersection for the lights, the Back Seat Driver should use a proximal deictic ("this" or "these", as opposed to the distal "that" or "those") to show it means the lights that are here.

The Back Seat Driver preferably has a database of buildings as part of its directory of services. If it finds a building on the corner, it should include it as a potential landmark: e.g. "Look for Merit Gas on the left side".

Other landmarks are features of the road, such as underpasses, bridges, tunnels, bends in the road, and railroad crossings. Still another potential landmark is the road coming to an end. This is a landmark that is impossible to miss. However, research has shown that if the Back Seat Driver says "Drive all the way to the end, then . . . ," some drivers take "the end" to mean not "the farthest you can go along this road" but just "the next intersection".

A street name can be a landmark, but not a good one, unless the driver already knows the street. There are several reasons why street names should not be used. First, the driver may not hear the name correctly. Second, the driver may hear the name, but not know how to spell the name after hearing it, so she may not recognize the name in its printed form. This is especially a problem when the driver is from out of town. Finally, even if the driver knows the spelling, street signs are often missing, turned around, or invisible due to weather or darkness. Despite all the problems that come with using street names, many drivers ask for them. To accommodate them, a parameter in the user-model is preferably included to control the use of names. If set, names are supplied as part of the instruction. When names are included, they are preferably attached at the end of the instruction ("Take the second left. It's Elm Street.") rather than directly ("Take the second left onto Elm Street."), which weakens their salience somewhat, and makes them more of a confirmatory cue than an essential one.

Signs can be important landmarks. A problem with using signs as cues occurs, however, if the information in the sign is stored as unstructured text in the map database. It is important that the Back Seat Driver understand what the sign says, not simply utter the words. There are two reasons for this. First, the Back Seat Driver's internal representation for text is preferably based on syntactic structure, not text strings. Second, the objects mentioned in the signs (cities and roads) should be entered into the discourse model to become salient for future reference. The Back Seat Driver should parse sign text by separating it into tokens delimited by commas and the word "and", and then attempt to recognize objects on the map (street names, cities, neighborhoods) from these tokens. When recognition fails, the token cannot be entered into the discourse model. When parsing fails, the spoken output will have incorrect grammar.

The Back Seat Driver does not assume that the driver will recognize the place to act (e.g. by seeing a street sign) so the driver must be told when (or where) to act. The Back Seat Driver uses timing ("Take a left here") when the driver has reached the place to act. The working prototypes calculate the place to speak by finding a distance from the intersection which is $v * (t_{speak} + t_{reaction})$, where t_{speak} is the time to speak the utterance and $t_{reaction}$ is the driver's reaction time. The time to speak depends on the number of words in the utterance. (The Dectalk synthesizer used in the prototypes speaks 180 words per minute.) Reaction time can be estimated to be two seconds.

The Back Seat driver speaks autonomously, but preferably provides means to allow it to speak on demand. The driver at any time should be able to ask for instructions immediately by, for example, pushing buttons representing "What next?" and "What now?". In addition, while following a route, a driver should be able to ask to hear the total length of the route and the remaining distance. A driver should also be able to ask to hear the name of the street the car is on and the compass direction the car is headed.

In order to generate more fluent text, the Back Seat Driver preferably keeps track of what has been mentioned. Some instructions are obvious after having been given. If the system tells the driver to go straight through a set of lights, there is no reason to repeat the instruction when actually at the lights. This is in contrast with a turn, where the driver hears advance instructions to know what to do, and immediate instructions to know when to do it. This can be important, for if the driver hears "go straight through the lights" twice, she may try to go through two sets of lights. To implement this, each instruction should be able to determine whether it is obvious after having been given once. When it is time to speak the instruction, if the instruction has already been given, and it is obvious once spoken, then it should not be spoken again.

The Back Seat Driver preferably retains a history of the route. This allows it to generate cue phrases for the instructions. If the route calls for doing the same thing twice in a row, the system uses the work "another" to indicate this doubling. This is important for polite behavior. If a passenger were to give a driver instructions by just saying "Take a right. Take a right. Take a left. Take a right.", pronouncing each the same, the passenger would be judged to be rude. The passenger's speech is not acknowledging the driver's actions or history. There are two ways for the passenger to acknowledge

the driver's work: using cue words ("Take a right. Take another right. Now take a left."), or using intonation. However, some speech synthesizers, such as the Dectalk used in the prototypes, does not support flexible control of intonation, so cue words are the only possibilty.

The Back Seat Driver preferably is able to warn the driver about dangers which can be inferred from knowledge of the road network. These dangers include driving above the speed limit, driving the wrong way on a one-way street, driving too fast for an upcoming curve, driving on a one-way street that becomes two-way ahead, merging traffic, "blind" driveways ahead, speed traps, poorly repaired roads, potholes, and dangerous intersections. The Back Seat Driver preferably attempts to determine hazards by reasoning about road conditions rather than requiring them to be built in to the map database.

Lane advice includes telling the driver which lane to get into (or stay out of) when applicable. The system gives lane advice as part of the instruction when approaching an intersection where it matters. The instruction may also include advice about what lane to be in after the intersection, in preparation for the next act.

Speed advice includes warning the driver to slow down if she is travelling too fast to safely negotiate a turn. The limiting factor for angular acceleration is the driver, not the cornering ability of the car. Research has shown that the average driver will accept no more an 0.1 G radial acceleration. Radial acceleration is v^2/r where r is the turning radius of the turn. The Back Seat Driver knows the geometry of the road, so it can predict the maximum tolerable velocity for the turn. It need not tell the driver about this speed (the driver will choose a comfortable speed without being told), but it should estimate the distance required to decelerate, and tell the driver to slow down early enough to do this gently.

If the driver leaves the route, the Back Seat Driver immediately informs the driver and begins to plan a new route. Telling the driver what she did wrong prepares her for hearing new instructions, and perhaps helps her learn to better interpret the style of language that the Back Seat Driver uses.

To describe an error, the Back Seat Driver needs to look back to the last action that the driver failed to perform. It should utter a description of this action, saying e.g. "Oops, I meant for you to take a right," which does not blame the driver as in e.g. "You made a mistake. You should have taken a right." A driver might leave the route deliberately; or the error could be system's, not the drivers.

Errors will occur due to inaccuracies in the location system. The Back Seat Driver is preferably able to model the uncertainty of a position. For instance, when two roads diverge at a narrow angle, it will be unable to distinguish which was taken until some distance passes. It should probably assume that the driver made the correct choice rather than taking the risk of making a false accusation. If it reaches a place where the difference is crucial, yet unknown, it is probably better for it to confess its uncertainty, and say something like "I'm not quite sure where we are, but if you can take a right here, do it, and if not, keep going, and I'll figure things out better in a minute." Or it might ask the driver to pull over and stop (if the driver is at a place where that is safe) to allow for a better position estimate by averaging a few successive estimates.

Errors will also occur if the database is somewhat out of date. The Back Seat Driver can regain at least a little confidence by how it explains the mistake. Suppose that the Back Seat Driver intends the driver to turn onto "Apple" Street, and says "Take a right at the next light". Unbeknownst to it, a new traffic light has been installed at "Pear" Street, so the driver turns there. It is somewhat confusing if the Back Seat Driver says "I meant for you to go straight," because the driver may think that the program has not been consistent. A better message would be "I did not mean for you to turn onto Pear. I thought that the next set of lights was at Apple Street."

While the driver is following a route, the Back Seat Driver preferably adopts a persistent goal of keeping the user reassured about her progress and the system's reliability. If the Back Seat Driver were a human, this might be unnecessary, since the driver could see for herself whether the navigator was awake and attending to the road and driver. But the driver cannot see the Back Seat Driver and so needs some periodic evidence that the system is still there. One piece of evidence is the safety warnings the system gives. But if all is going well, there will not be any. Other kinds of evidence that things are going well should be provided. When the user completes an action, the Back Seat Driver can acknowledge the driver's correct action, saying something like "nice work" or "good". Also, insignificant remarks about the roads nearby, the weather and so on, can be provided. The driver then assumes that everything is going well, for otherwise the Back Seat Driver would not speak of trivial matters.

The Back Seat Driver should know about the knowledge and desires of its driver, and act differently because of this knowledge. This knowledge is preferably incorporated in a user-model.

For driver properties which do not change or change very slowly, such as colorblindness, or visual or aural acuity, it is acceptable for the Back Seat Driver to ask the user for such knowledge. However, for other driver properties, the Back Seat Driver preferably acquires a model of the user automatically, without asking or having to be told. For example, the Back Seat Driver could learn the driver's reaction time by measuring the time between its speech and the driver's operation of the controls.

The Back Seat Driver preferably learns the style of instruction giving appropriate for the driver. To learn the driver's preferences for route description requires either observation of the driver herself giving instructions or getting feedback from the driver about the instructions the system provides.

The driver can provide feedback about the suitability of the Back Seat Driver's instructions either explicitly or implicitly. One explicit indication of comprehension is how often the driver hits the "what now?" button. The system might collect long term statistics on the types of intersections where the user most often requests help, and begin to offer instructions without being asked. Just as the user can ask for more talking with the "what now" button, the Back Seat Driver should provide a "shut up" button (or other means to the same effect). The Back Seat Driver could also learn the effectiveness of its directions simply by watching the driver's performance—in particular, her errors. In this way, it can learn which cues are most effective.

Another opportunity for learning the driver's style is during the acquisition of speech recognition templates

(for user-dependent speech recognition for driver input means, described below). The new user should play the role of a "back seat driver" and give instructions, while in a car, for some route. The instructions must be given while driving either a real car or a close simulation because the form of static driving instructions is much different from real time instructions. Given some a priori knowledge about the ways that a route can be described, it is not impossible that the system could understand the instructions, and infer style from it. A difficulty here is that if the driver knows the route well, many things will seem obvious to her that would not be obvious to another person.

If the Back Seat Driver knows what the driver knows about the city, it can give better directions. A user who knows about a city no longer need instructions, she needs information about structure. The object description system preferably provides novice users a process description which emphasizes casual connections, and experts structural descriptions. Experts do not need the casual information, they can derive it for themselves.

The attributes of the user-model preferably include:

route-preference—does the driver want the fastest, shortest, or simplest route?

reassurance-period—how often should the program speak to the driver?

use-names—should the program tell the driver the names of passing streets?

congratulate-after-act—should the program make an explicity acknowledgment of correctness to the driver after each act?

obvious-to-cross-major—can the program assume that the driver will continue straight across a major intersection without being told explicitly to do so?

scoflaw—does the driver want to be warned when she is speeding?

daredevil—does the driver want warnings when driving dangerously fast?

distance-lowpass—does the driver want to be told the distance to the next action (in yards or miles, as appropriate). Most drivers do not understand distances in tenths of miles, so by default the program mentions only those distances that exceed one half mile.

The functions of the user-model preferably include:

obvious-next-segment—given a current position, is there a unique segment such that it is almost certain the driver will go there, without being told to do so?

at-major-intersection—is the current intersection one that the driver would call "major"?

extrapolate-path—try to predict the path the driver will follow in the next N seconds, assuming she does only what is obvious.

maximum-safe-speed—calculate the maximum speed at which the driver can get through an intersection. This calculation is based on finding the segment with the greatest radius of turn, and then calculating the largest speed the vehicle could have while making that turn without undergoing unacceptable sideways acceleration.

For the Back Seat Driver to decide what to say and when to say it, it preferably has a model of the vehicle performance. It must know, for example, how slowly the car should be going in order to safely make a turn. A suitably instrumented car could also measure the coefficient of friction by comparing the applied braking force and the resulting deceleration. This would allow it to adjust the time factors used in deciding when to speak.

The Back Seat Driver should understand the driver's plans and goals. When a driver enters a destination address, she is telling the system that she has the goal of getting to that address. The Back Seat Driver might guess at higher level plans from knowledge about the destination, and take actions to assist the driver with those plans. To do this, it must know what kind of thing is at the destination address. For instance, if the address provided is that of a store, the Back Seat Driver can guess that the driver is going there to purchase something, or at least to do business there. It could check the hours that the store is open.

The Back Seat Driver should help drivers to understand the route it gives. This would make the system more pleasant to use. It would also make it easier to follow routes because a driver who understands the route and the city will use that knowledge to help interpret the commands Back Seat Driver gives. A route should fit into a larger model of the city. This means that the Back Seat Driver itself must have a model of the city and should speak of the route in terms that relate it to the city. There are several opportunities to do this. At the beginning of the route, the driver might hear an overview of the route, naming the major paths followed and neighborhoods crossed. During the route, locations could be described not just as street address but in larger units of neighborhoods and districts. Orienting information can be included in instructions, or it might come between instructions, as a passing comment.

There are some additional services that the Back Seat Driver could easily provide. It should be able to give the location of a place without giving directions, it should be able to give the directions all at once, and it should be able to give directions between any two places. A driver might want to use these to tell someone else how to get to where they are.

The Back Seat Driver should be able to communicate with the outside world if the outside world is equipped to talk to it. For instance, after determining that a given parking garage is the closest or most convenient to the current destination, the Back Seat Driver could automatically phone or radio the garage and reserve a space.

The Back Seat Driver should be running on a computer embedded in the car, so that it can get more and better information about the state of the car and driver. For instance, when the next instruction is a turn, the Back Seat Driver should notice whether and when the driver turns on the turn signals. If the driver applies them too soon, it is possible (but not certain) that the driver has underestimated the distance to the turn; if applied at the "right time" then the system can take that the action has been understood; if never applied, then the driver has either misunderstood, or is driving hazardously.

The Back Seat Driver should also be integrated into the car's audio system, rather than having separate systems for voice and music. Furthermore, it should pay attention to what the driver is listening to. If the driver is listening to the radio, or playing a CD (or using a cellular telephone) the program should try to speak less often, on the grounds that the driver has implicitly indicated a preference for what to listen to. The program should suppress reminders and historical notes altogether. When it must speak, it should borrow the audio channel rather than trying to speak over it. The Back Seat Driver should also be aware of the driver's use of other controls in the car. It should defer speech

while the driver is adjusting the heat or the mirrors, for example, and suppress speaking altogether if the car makes sudden extreme changes in velocity. A driver trying to cope with an emergency situation does not need another distraction.

The discourse model preferred for the Back Seat Driver is a partial implementation of the discourse theory described by B. J. Grosz and C. L. Sidner ("Attention, intentions, and the structure of discourse" in *Computational Linguistics*, 12(3):175-204, 1986) and the theory of intonational meaning described by J. Hirschberg and J. Pierrehumbert ("The intonational structuring of discourse" in *Proceedings of the Association for Computational Linguistics*, 136-144, July 1986). Both of these articles are herein incorporated by reference. This model allows the program (or programmer) to create and manipulate discourse segments. The program specifies the contents of the discourse segment (both the syntactic form and the list of objects referenced) and the implementation of the model does the following: generates prosodic features to convey discourse structure; inserts discourse segment into intentional structure; and maintains attentional structure—adding new objects when mentioned and removing old objects when replaced. In addition it includes some useful low-level tools for natural language generation: search of attentional structure for occurence of co-referential objects; conjugation of verbs; generation of contracted forms; and, combination of sentences as "justification" sentences (e.g. "get in the right lane because you are going to take a right.") and sequential sentences ("Go three blocks, then turn left"). In order to use the discourse package the programmer must explicitly declare all semantic types used by the program, so in this case there are declarations for all objects which pertain to driving, such as street names, bridges, rotaries, stop lights and so on.

SPEECH GENERATOR

In the working prototypes of the Back Seat Driver, speech generation is performed by Dectalk, a commercial text-to-speech speech synthesizer, which is cabled to the main computing apparatus.

An alternative to synthesized speech is digitized speech, which is easier to understand than synthetic speech. Digitized speech, however, requires a great deal of storage space. There are more than 2000 different street names in Boston. Allowing another 500 words for the actual instructions, and assuming an average duration of 0.5 seconds for each word, coding this vocabulary at 64 kilobits per second would require 10 megabytes of speech storage. Given a Back Seat Driver that uses a CD-ROM for the map, the digitized speech could be stored on the disk as well. Coded speech would be more intelligible than synthesized speech, and less costly, but not as flexible. For, example, it would be impossible to read electronic mail using only stored vocabulary speech.

The generated speech is spoken to the driver through some kind of speaker system in the car. In a simple embodiment, the speaker system of the car radio is used.

DRIVER INPUT MEANS

Means for the driver to communicate with the backseat driver are required. For example, the driver must be able to enter destination addresses, request instructions or a repeat of instruction, and inform the Back Seat driver when an instruction cannot be carried out

for some reason. In embodiments where the computing apparatus is installed in the automobile, a computer keyboard can be adapted to provide this communication means.

In one working prototype of the Back Seat Driver, the computing apparatus is not installed in the automobile, but is accessed through a cellular telephone. In this embodiment, the driver communicates with the Back Seat Driver by using the cellular telephone keypad. Address entry is achieved by first entering the digits, then a number sign, then spelling the street name using the letters on the telephone keypad. The letters "Q" and "Z" are on the "6" and "9" keys, respectively, and the space character is on "1", which is otherwise unused. These keys are sufficient to spell any street name in Boston. The spelling rules can be easily expanded to enter street names with other characters in them, for example, "4th Street".

In the implementation, spelling a street name requires only one button push for each letter, even though there are three letters on each key. This is because of the redundancy in street names, which are pronounceable words, not arbitrary strings. There are 37 pairs of street names in Boston with the same "spelling" in the reduced "alphabet". An example is "Flint" and "Eliot", both encoded as "35468". This is only one percent of the 2628 names of streets in Boston, so collisions are rare. This technique appears workable even for larger sets of names. When the entire word list of the Brown corpus is encoded, there are still only 1095 collisions in the 19,837 words (5.5%).

If a name collision occurs, the Back Seat Driver reads the list of possibilities, and asks the driver which one was meant. This is very rare. A more common problem is that street names are duplicated. When this happens, the Back Seat Driver asks the user a series of questions to reduce the list to a single choice. It tries to ask the fewest questions possible. It asks the user to choose from a list of street types, if that is sufficent to resolve the question, and otherwise from a list of the containing cities (or neighborhoods, if there are two instances within a single city). To select from a list, the Back Seat Driver reads the contents, asking the user to push a button when the desired choice is read.

The Back Seat Driver would be much easier to use if the driver could simply talk to it instead of using a keyboard or keypad. Speech recognition could be used for driver input means, however, address entry is a difficult task for speech recognition for the same reason it is hard for a human to understand machine speech—there are few constraints on a name. No speech recognizer available today can handle a 3000 word vocabulary with acceptable error rates. The car would also have to be stopped while the driver was speaking, because noise in moving cars for frequencies below 400 Hz can exceed 80 dB.

Back Seat Driver could also use speech recognition to replace the "What now?" and "What next?" buttons. This is a more tolerant application for speech recognition because there are fewer words to recognize.

SYSTEM PROCESSES

The Back Seat Driver carries out three separate tasks, each of which is executed by its own process. All processes share the same address space, so all variables and functions are accessible in every process, and no special mechanism for interprocedure call is required. Where necessary for synchronization, Back Seat Driver uses

queues or locks. All three processes are simple, infinite loops. The system processes are illustrated in FIG. 2.

The user process is the main process of the Back Seat Driver. It is this process which finds routes and gives instructions to the driver. The user process manages a list of goals. Each time around the loop, it selects a goal to work on, and does something to achieve the goal. if possible. The user process is connected to the speech generator, since that is how it talks to the driver.

The navigator process maintains an estimate of the current position and velocity of the car. It is connected to the position sensor by a serial line. Preferably, packets arrive from the position sensor several times a second. The navigator converts the data in the packets from the position sensor format to the format used by the Back Seat Driver.

There are two minor processes which assist the navigator process: The average speed process computes the running average speed of the vehicle over the last five seconds. It could be made part of the navigator process, but is distinct because it is more convenient that way. The position sensor monitor process keeps track of how often packets arrive. If packets do not arrive when scheduled, it should set a flag to indicate this to inform the driver if the position sensor ceases to work properly.

The control process is responsible for controlling the Back Seat Driver as a whole. The control process is connected to driver input means for entering, for example. the destination and requesting additional instructions while driving (e.g. the "What now"?, "What next?" and "I can't do it" features.) Other functions of the control process are useful in a research prototype, but should not be required in a commercial embodiment of the Back Seat Driver. One such function is debugging.

The user process is a goal-driven perpetual loop which seeks to use the resources available to it to satisfy as many goals as possible as quickly as possible, devoting resources first to those goals which are of greatest importance. There are two aspects to this process, goal structures (which names goals) and goal-functions (which tell how to accomplish them). A goal is just a name, a priority (a number). and a set of slots (parameters). Thus for instance a typical goal would be (GET-TO-PLACE<140 Elm Street>). where the goal has one slot. namely the destination. A goal-function is a function which is possibly able to achieve a goal. When a new type of goal is defined, the programmer also tells the system which goal functions can possibly meet it, and later, when the system tries to accomplish a goal it selects from this list.

The goal loop is a three step process. 1) Check to see whether there are any newly added goals. The driver can add a goal by hitting a key, and the system can also add goals. 2) Find the most important goal to work on. 3) Work on that goal. In general, systems should use resources in the most efficient manner possible. For the Back Seat Driver, the only resource is speaking time. The only way the Back Seat Driver can accomplish any of its goals is by speaking. Speech is a resource because the program can only say one thing at a time, and speaking takes a finite time. It is also important to note that spoken utterance has a useful effect only if completely spoken, so it is not helpful to begin to speak if there is not time to complete the speech.

The protocol for a goal function preferably includes the following:

progressable?—Is the goal able to accomplish anything at this time?

resource-used—If it runs now, what resources will it want to use?

maximum-time-of-resource—If it runs now, how long (in seconds) will it need each resource?

minimum-time-to-resource—The minimum time that it can estimate until it may again need this resource, and the priority of its use at that time.

In the working prototypes of the Back Seat Driver, the list of all goals is stored in the global variable *goals*. The goal loop and goal structures are defined in the file goals.lisp. The various goals and goal functions of the Back Seat Driver are defined in the files main.lisp, route-goals.lisp, and get-to-place.lisp. All goals which use speech are built from the speech-goal object defined in speech-goal.lisp. The speech resource itself is defined in speech-resource.lisp.

The goal or function which gets a user to a destination is called GET-TO-PLACE. An explanation of this goal will illustrate the goal mechanism in more detail, as well as illustrate how this most important function of Back Seat Driver is implemented. The goal GET-TO-PLACE, has two slots, destination which is the location the user wants to get to, and route which is the route the Back Seat Driver intends to use to get there.

The driver adds the goal to the system goal list by striking a key. When the goal is first created, the destination is not known (the destination slot is empty), so the goal function for GET-TO-PLACE creates a sub-goal, GET-DESTINATION, and adds it to the goal list. Now there are two goals on the goal list, GET-TO-PLACE and GET-DESTINATION, but only the second is progressable, because when a goal has a sub-goal, it is not allowed to run until the sub-goal finishes. Therefore, the only progressable goal is GET-DESTINATION, which attempts to get a destination by asking the user to enter an address. If the user fails to do so, the subgoal fails, which in turn causes GET-TO-PLACE to fail, and the Back Seat Driver says "Travel cancelled". Otherwise, it writes the destination into the destination slot of the GET-TO-PLACE goal. Now that the sub-goal is complete, GET-TO-PLACE can once again make progress. This time it finds that the route slot is empty, and again calls for the sub-goal GET-ROUTE, which calculates a route. When this is complete a third subgoal is invoked, namely FOLLOW-ROUTE.

The goal function for FOLLOW-ROUTE gets the driver to the destination by speaking instructions. If something goes wrong (for example if the driver makes a mistake) then the subgoal fails. But this does not make GET-TO-PLACE give up. Instead, it erases the route slot, and simply finds a new route, and then tries FOLLOW-ROUTE again. This continues, no matter how many times things go astray, until either FOLLOW-ROUTE succeeds, or the driver cancels the trip.

The goal FIND-SERVICE is similar to GET-TO-PLACE except the driver selects a kind of service (for example, a gas station), and then the Back Seat Driver finds the closest provider of that service, and then finds a route to it. Following that route is done by FOLLOW-ROUTE in the same way as for GET-TO-PLACE.

The FOLLOW-ROUTE goal function gets the user to her destination by giving spoken instructions. There are several reasons it might speak:

at the beginning, to alert the driver

to give an instruction in advance, so the driver will be ready
to give an instruction when it is time to do it
to confirm that the driver has correctly carried out an instruction
to inform the driver of her arrival at the destination
to reassure the driver that she is still on route
to inform the driver of a mistake
to warn the driver that she is driving so fast that the program cannot keep up.

FOLLOW-ROUTE decides the next reason for speaking by first trying to locate the current position on the path. If the position is not on the path (more precisely, if the current segment does not occur anywhere on the path) then the driver has left the path (or the position sensor has made an error). Otherwise, FOLLOW-ROUTE determines what instruction must be next executed by calling the function next-driver-instruction.

The goal function protocol requires that FOLLOW-ROUTE support the goal function minimum-time-to-resource, which estimates the minimum time until FOLLOW-ROUTE will next speak. This time depends upon the reason for the next speaking. FOLLOW-ROUTE speaks immediately when beginning, confirming, warning, or finishing the route. When the driver is off the route, FOLLOW-ROUTE waits a few seconds before speaking, just in case the driver's departure from the route is actually a temporary error by the position sensor.

Given that the driver is on the path, FOLLOW-ROUTE determines when to speak by calculating the position where it must begin speaking the instruction text, then estimating the time required to reach that position at the driver's current speed. As the driver's speed changes, so will this estimated time. The position to begin speaking is calculated by first finding the position where the instruction is executed, then moving back a distance to allow the Back Seat Driver time to speak the text and the driver to react to it.

The Back Seat Driver can also give instructions in advance, if desired. It does this in much the same way, except that it adds an additional number of seconds (normally thirty) to the time estimate, and so begins to speak much sooner. When it gives instructions in advance the instruction text is longer because the program has more time to speak.

When the driver leaves the route FOLLOW-ROUTE starts a timer. If the driver has not returned to the route by the time the timer goes off (at present, two seconds) then FOLLOW-ROUTE checks for a possible mistake. In describing the mistake, it attempts to characterize what the driver actually did as well as what the program intended the driver to do. It is able to do this because in the main loop it stored the last position that the driver was on when last on the route.

Goals may interrupt lower priority goals by requesting the speech resource to interrupt the lower priority goal. Interruption stops the speech synthesizer immediately. The interrupted goal is informed of the interruption, and can react as it chooses. There is no way for the goal to know whether any of its words were actually spoken, so it has to start all over. Most goals attempt to run again as soon as possible. The assumption is that the interruption occurred because the user started some higher priority goal after learning how to do so through the help command.

The system treats "repeat the last statement" as a goal, rather than as a special purpose function, except that the importance of this goal is set to the value of the last goal spoken (the goal whose utterance is being repeated). This guarantees that if some more important goal desires to speak, it will be able to. A repetition of an utterance is no more important than it was originally.

Goals can be temporary or presistent. Temporary goals can be satisified, but persistent goals never can be. All system initiated goals are persistent. The system goals include warning the driver of dangers ahead (WARN-DRIVER) and informing the user of new electronic mail or other messages (if the computer apparatus of the Back Seat Driver is connected to the outside world). These goals can never be satisified. The driver's safety should always be preserved and mail or messages can arrive at any time.

CELLULAR PHONE EMBODIMENT

The Back Seat Driver is preferably an in-car navigation system, but in some embodiments, it may be desirable to not have the entire computing apparatus installed in the car. This is the case if the computing apparatus is too large or if a number of cars are to share a single computing apparatus.

For such embodiments, two cellular phones installed in the car can be used to transmit data from the car to the computing apparatus, and to receive voice from the speech generator in the computing apparatus. In this embodiment, data from the position sensor installed in the automobile is sent through a cellular phone in the car equipped with a modem to a phone connected to the computing apparatus via a modem. The voice generating apparatus of the computing apparatus sends speech over another phone to a second cellular phone installed in the automobile.

This embodiment has been implemented in a working prototype, using a large workstation computer (a Symbolics Lisp Machine). In this implementation, a position sensor installed in the car estimates vehicle position, heading, and velocity, and sends a data packet, once per second, through a modem to the workstation. The workstation sends characters to a Dectalk speech synthesizer, which in turn sends voice over a second phone to the driver.

Nearly everyone who has used a cellular phone knows how noisy they are. Cross talk is common and noise bursts and signal loss make it hard to hear. A sufficiently bad noise burst can even cause the cellular system to terminate the call. The problems for data transmission are even worse. By its very nature, cellular radio transmission is subject to multi-path interference, which causes periodic fades as the antenna moves in and out of anti-nodes. In addition to this fading, there is a complete loss of audio signal for as long as 0.9 seconds when the phone switches from one cell site to another (hand off).

An attempt to use an ordinary (land-line) modem from the car was unsuccessful. In the prototype, a Worldlink 1200 from Touchbase Systems was used in the car, with a Morrison and Dempsey AB1 data adapter, and an NEC P9100 phone, boosted to 3 watts. At the base station, both a Practical Peripherals 2400 and a Hayes Smartmodel 1200 were used. Even at 300 baud the connection was too noisy to use. Worse, connections seldom lasted more than five minutes. In all cases, the "loss of carrier" register (S10) was set to its maximum value, 20 seconds. Loss of carrier signal alone

cannot explain why the connections dropped. The modems were capable of tolerating a complete loss of audio for up to twenty seconds.

Better results were found using an error correcting modem (The "Bridge") made by the Spectrum Cellular Corporation. This modem uses a proprietary protocol (SPCL) for error correction. The Spectrum product virtually eliminated noise, at the price of a lower data transmission rate. According to the protocol, the transmitting modem groups characters into packets that include error correction bytes. If only a few errors occur, the receiving modem repairs the data and acknowledge receipt. If there are many errors, the packet is retransmitted. If the sending modem has to retransmit too often it makes the packets smaller, on the assumption that a smaller packet has a better chance of success. This is less efficient, since packets have a fixed overhead, the percent of the channel used by data decreases. When conditions improve the modem increases packet size again. In theory, the modem can transmit at 120 characters per second, but tests made by recording the time required to receive the three characters of an odometer sequence demonstrated that the average value is closer to 30 characters per second. This sequence is transmitted once per second. The mean for durations for the three character sequences is 94 milliseconds, which is 31 milliseconds per character, or 32 characters per second.

Even with the cellular modem, calls are sometimes dropped. The call durations are usually long enough for a successful trip with the Back Seat Driver. Voice calls are dropped at about the same rate as data calls.

The protocol used by the Spectrum modem acknowledges all data transmitted. If the acknowledgment is not received, it retransmits the data until acknowledged. Under adverse conditions, this can result in an arbitrarily long delay. This is a problem when real-time data is transmitted. Observation of the Back Seat Driver shows that sometimes the system will "freeze" for from one to ten seconds. During this time, the car of course continues to move. If these freezes occur near decision points, the driver may go past the intersection without being told what to do. At 20 miles per hours a car travels nearly 45 meters in five seconds. The navigation system in the car sends a packet once every second. Most packets arrive within a second, but a few are delayed, some by up to ten seconds. (These delays may also arise from delays at the workstation. Lisp Machines are not noted for real-time response.)

It would be better to have a protocol which guarantees to deliver data intact and free of errors, if it delivers it at all, but does not guarantee to deliver the data. Real time data is only valuable in real time, and time spent retransmitting old data is taken away from ever, more valuable data. Such a protocol modification is feasible for the Spectrum product.

What is claimed is:

1. An automobile navigation system which produces spoken instructions to direct a driver of an automobile to a destination in real time comprising:

computing apparatus for running and coordinating system processes,

driver input means functionally connected to said computing apparatus for entering data into said computing apparatus, said data including a desired destination,

a map database functionally connected to said computing apparatus which distinguishes between physical and legal connectivity,

position sensing apparatus installed in the automobile and functionally connected to said computing apparatus for providing said computing apparatus data for determining the automobile's current position,

a location system functionally connected to said computing apparatus for accepting data from said position sensing apparatus, for consulting said map database, and for determining the automobile's current position relative to the map database,

a route-finder functionally connected to said computing apparatus, for accepting the desired destination from said driver input means and the current position from said location system, for consulting said map database, and for computing a route to the destination,

a discourse generator functionally connected to said computing apparatus for accepting the current position from said location system and the route from said route finder, for consulting said map database, and for composing discourse including instructions and other messages for directing the driver to the destination from the current position,

a speech generator functionally connected to said discourse generator for generating speech from said discourse provided by said discourse generator, and

voice apparatus functionally connected to said speech generator for communicating said speech provided by said speech generator to said driver.

2. The automobile navigation system of claim 1 wherein said map database comprises a set of straight line segments and a set of nodes, each endpoint of each segment being a pointer to a node representing the coordinates of the endpoint and the set of other segments which are physically and legally connected to that endpoint.

3. The automobile navigation system of claim 1 wherein said map database is based on DIME files of the United States Census extended to represent physical and legal connectivity.

4. The automobile navigation system of claim 3 wherein said DIME file is further extended to distinguish bridges, underpasses, tunnels, rotaries, and access ramps from other street types.

5. The automobile navigation system of claim 1 wherein said map database is based on TIGER files of the United States Census and United States Geological Survey extended to represent physical and legal connectivity.

6. The automobile navigation system of claim 5 wherein said TIGER file is further extended to distinguish bridges, underpasses, tunnels, rotaries, and access ramps, from other street types.

7. The automobile navigation system of claim 1 wherein said map database comprises a three-dimensional representation of street topology.

8. The automobile navigation system of claim 1 wherein said map database includes measures of street quality.

9. The automobile navigation system of claim 1 wherein said map database distinguishes divided streets.

10. The automobile navigation system of claim 1 wherein said map database includes landmarks such as signs, traffic lights, stop signs and buildings.

11. The automobile navigation system of claim 1 wherein said map database includes lane information.

12. The automobile navigation system of claim 1 wherein said map database includes speed limits.

13. The automobile navigation system of claim 1 wherein said map database includes expected rate of travel.

14. The automobile navigation system of claim 1 wherein said map database includes time-dependent legal connectivity.

15. The automobile navigation system of claim 1 wherein said map database includes turn difficulty.

16. The automobile navigation system of claim 1 wherein said map database includes vehicle street, lane, and height restrictions.

17. The automobile navigation system of claim 1 wherein said map database includes traffic light cycles.

18. The automobile navigation system of claim 1 wherein said map database distinguishes where right turn on red is allowed.

19. The automobile navigation system of claim 1 wherein said map database includes a database of service locations.

20. The automobile navigation system of claim 1 wherein said map database includes a listing of famous places by name.

21. The automobile navigation system of claim 1 further comprising means for updating said map database.

22. The automobile navigation system of claim 1 further comprising means for updating said map database by radio broadcast.

23. The automobile navigation system of claim 1 wherein the map has minimum accuracy of 10 meters.

24. The automobile navigation system of claim 1 wherein said route finder is based on a best-first search algorithm.

25. The automobile navigation system of claim 1 wherein said route finder is based on an A* algorithm.

26. The automobile navigation system of claim 1 wherein said route finder is based on an A* algorithm modified to find a route in less time.

27. The automobile navigation system of claim 1 wherein said route finder is adapted to find a best route according to any one of three cost metrics: distance, speed, simplicity.

28. The automobile navigation system of claim 1 wherein said route finder is adapted to calculate a new route if the driver or vehicle navigation system makes an error or if the route is unnavigable due to unforeseen circumstances, wherein said new route does not simply backtrack to the point of the error if a better route from the current location exists.

29. The automobile navigation system of claim 1 wherein said route finder is adapted to calculate a new route while the automobile is in motion, wherein said new route will begin from the location of the automobile at the time the calculation of the new route is completed.

30. The automobile navigation system of claim 29 wherein an estimated time to find a new route is multiplied by the velocity of the automobile to calculate the position from which the new route should start.

31. The automobile navigation system of claim 30 wherein said estimated time to find a new route is calculated by multiplying the distance between the starting and ending points of the new route by a constant.

32. The automobile navigation system of claim 1 wherein said location system is a position-keeping (dead-reckoning) system.

33. The automobile navigation system of claim 1 wherein said location system is a hybrid of position-keeping and position-finding systems.

34. The automobile navigation system of claim 1 wherein said location system employs map matching.

35. The automobile navigation system of claim 1 wherein said position sensing apparatus comprises displacement and direction sensors installed in the automobile.

36. The automobile navigation system of claim 1 wherein said position sensing apparatus measures displacement with an odometer.

37. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a magnetic compass.

38. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction by monitoring the turning of the steering wheel.

39. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a differential odometer.

40. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a gyroscope.

41. The automobile navigation system of claim 1 wherein said discourse generator is based on an object-oriented programming methodology.

42. The automobile navigation system of claim 1 wherein each intersection in a route is classified into one type in a taxonomy of intersection types, and the disclosure generated in relation to each said intersection depends on its type.

43. The automobile navigation system of claim 42 wherein said taxonomy of intersection types includes continue, forced-turn, U-turn, enter, exit, onto-rotary, stay-on-rotary, exit-rotary, fork, turn, and stop.

44. The automobile navigation system of claim 42 wherein said discourse generated further depends on a description function for each intersection type which generates a description given the length and tense of the desired description and the position along the route from which an instruction is to be given.

45. The automobile navigation system of claim 1 wherein said discourse generated comprises a long description of an act given substantially before the act is to be performed and a short description given at the time the act is to be performed.

46. The automobile navigation system of claim 45 wherein said long descriptions includes cues.

47. The automobile navigation system of claim 46 wherein said cue is a landmark.

48. The automobile navigation system of claim 1 wherein said driver input means includes means for said driver to demand immediate instructions, or clarification or repetition of instructions already provided.

49. The automobile navigation system of claim 1 wherein said driver input means includes means for said driver to indicate to said automobile navigation system that a given instruction provided by said system is impossible to complete for some reason and that a new route must be calculated.

50. The automobile navigation system of claim 1 wherein said driver input means comprises a voice recognition system to allow at least some driver input to be spoken.

51. The automobile navigation system of claim 1 wherein said automobile navigation system records a history of the route and the discourse already generated and uses this knowledge to generate cues for future discourse and make future discourse more understandable.

52. The automobile navigation system of claim 1 wherein said automobile navigation system warns drivers of dangers inferred from knowledge of the road network.

53. The automobile navigation system of claim 1 wherein said automobile navigation system informs a driver if an error has been made as detected by the location system.

54. The automobile navigation system of claim 1 wherein said discourse generator is responsive to a user-model stored in said computing apparatus to customize discourse to the requirements and preferences of said driver.

55. The automobile navigation system of claim 1 wherein said speech generator is a speech synthesizer.

56. The automobile navigation system of claim 1 wherein said speech generator uses digitized speech.

57. The automobile navigation system of claim 1 wherein said computing apparatus is not installed in the automobile, and said automobile navigation system further comprises means for communication between said computing apparatus and the automobile navigation system components installed in the automobile.

58. The automobile navigation system of claim 57 wherein said means for communication is two cellular phones in said automobile, one of which is connected to a modem, and two phones connected to said computing apparatus, one of which is connected to a modem, whereby one data channel and one voice channel between said automobile and said computing apparatus is created.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,177,685 Page 1 of 2

DATED : January 5, 1993

INVENTOR(S) : James R. Davis, et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 18: after "all" please insert "three";

Column 7, line 50: delete "street" and insert therefor -- streets --;

Column 11, line 11: after "algorithm" please insert ", ";

Column 11, line 66: after "compass" and before "A" please insert ": ";

Column 12, line 4: after "wheel" and before "The" please insert ": ";

Column 12, line 6: after "odometer" please insert ": ";

Column 12, line 14: after "gyroscope" and before "Gyroscope" please insert ": ";

Column 16, line 36: delete "to also" and insert therefor -- also to --;

Column 17, line 18: delete "its" and insert therefor --it is --.

Column 17, line 18: delete "that";

Column 17, line 20: delete "if" and insert therefor -- is --;

Column 17, line 18, delete "it".

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,177,685

DATED : January 5, 1993

INVENTOR(S) : James R. Davis, et al.

Page 2 of 2

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, line 61: delete "work" and insert therefor -- word --;

Column 21, line 16: delete "need" and insert therefor -- needs --;

Column 21, line 19: delete "casual" and insert therefor -- causal --;

Column 21, line 21: delete "casual" and insert therefor -- causal --;

Column 28, line 8: delete "presistent" and insert therefor -- persistent --;

Column 29, line 13: delete "knowledge" and insert therefor -- knowledges --;

Column 32, line 33-34: delete "disclosure" and insert therefor -- discourse --; and

Column 32, line 52: delete "includes" and insert therefor -- include --.

Signed and Sealed this

Fifteenth Day of March, 1994

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

EXHIBIT 2

5177685

IAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/569,274	08/09/90	364	443 449	2324	Pipala

JAMES R. DAVIS, NORTH CAMBRIDGE, MA; CHRISTOPHER M. SCHMANDT, MILTON, MA.

CONTINUING DATA*******************
VERIFIED

NONE

FOREIGN/PCT APPLICATIONS**********
VERIFIED

NONE

VERTIFICATE
MAR 15 1994
OF CORRECTION

FOREIGN FILING LICENSE GRANTED 09/22/90

Foreign priority claimed / 35 USC 119 conditions met ☐ yes ☐ no / Verified and Acknowledged / Examiner's Initials	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
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[illegible]
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[illegible]
[illegible] STREET
BOSTON, MA 02109

AUTOMOBILE NAVIGATION SYSTEM Using Real Time Spoken [illegible] Instructions

U.S. DEPT. of COMM.- Pat. & TM Office-PTO-436L (Rev. 10-78)

PARTS OF APPLICATION
FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED	PREPARED FOR ISSUE 7-2-92		CLAIMS ALLOWED	
6/30/92	Edward Pipala / Assistant Examiner	Parooj Hanna / Docket Clerk	Total Claims: 58	Print Claim: 1

ISSUE FEE			DRAWING		
Amount Due: $1130.00	Date Paid: 9-25-92	PARSHOTAM S. LALL / SUPERVISORY PATENT EXAMINER / ART UNIT 234 / Primary Examiner	Sheets Drwg.: 3	Figs. Drwg.: 5	Print Fig.: 1

ISSUE CLASSIFICATION		ISSUE BATCH NUMBER
Class: 364	Subclass: 443	[illegible]

Label Area

WARNING: The information disclosed herein may be restricted. Unauthorized disclosure may be prohibited by the United States Code Title 35, Sections 122, 181 and 368. Possession outside the U.S. Patent & Trademark Office is restricted to authorized employees and contractors only.

Form PTO-436A
Rev. 8/89

APPROVED FOR LICENSE

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[redacted]

Entered or Counted	CONTENTS	Received or Mailed
	1. Application papers.	
	2.	8-28-90
	3. Fees + Decl.	09-10-90
	4. Prior Art	09-07-90
	5.	
	6. Ext. time 3-mos.	5-7-92
6-4	7. Amdt. A + Prior Art	5-7-92
	8. Notice of Allow	6/30/92
	9. Formal Drwg (3 shts)	9/04/92
	10. PTO GRANT JAN 05 1993	
	11. Req C of C R-322 + 323	4-28-93
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MIT 00267

PATENT APPLICATION SERIAL NO. 07 565274

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

070 LH 08/16/90 07565274 1 201 419.00 CK

PTO-1556
(5/87)

Loc 036 #4 A/N

In the United States Patent and Trademark Office

Applicant : James Raymond Davis and Christopher M. Schmandt Examiner :
Serial No. : 565,274 Art Unit :
Filed : August 9, 1990
For : Automobile Navigation System

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Information Disclosure Statement

Sir:

Aspects of the invention have been described in the following sources which were incorporated by reference in the specification and are listed on the attached PTO-1449. Copies are enclosed.

1. "Synthetic speech for real time direction-giving," by C.M. Schmandt and J.R. Davis (*Digest of Technical Papers, International Conference on Consumer Electronics*, Rosemont, Illinois, June 6-9, 1989) is an abstract describing the goals of the research which resulted in the present invention.

2. "Synthetic speech for real time direction-giving," by C.M. Schmandt and J.R. Davis (*IEEE Transactions on Consumer Electronics*, 35(3):649-653, August 1989) is an expansion of the above abstract into a paper. (Kindly note that the publication date for this issue was September 8, 1989, as indicated in the accompanying copy of the certificate of copyright registration.)

3. "The Back Seat Driver: Real time spoken driving instructions," by J.R. Davis and C.M. Schmandt (*Proceedings of the IEEE Vehicle Navigation and Information Systems Conference*, Toronto, Canada, September 1989) describes the strategies employed by the present invention to successfully use speech.

4. "Back Seat Driver: Voice assisted automobile navigation," by J.R. Davis (Ph.D. thesis, Massachusetts Institute of Technology, September 1989) is the most detailed publication describing the present invention to date. The thesis includes a long list of references. Those deemed by the applicants relevant to the present invention as claimed are included on the enclosed PTO-1449 and are discussed below. If the examiner requires further information regarding any of the references cited in the thesis but not included in this Information Disclosure Statement, the applicants will be pleased to provide such.

A short news article on the invention appeared in the July 1990 issue of *Technology Review*. The article, entitled "Terminal Back Seat Driver," is listed on the attached PTO-1449 and a copy of the article is enclosed.

The following references were incorporated and discussed in the the specification. They are listed on the attached PTO-1449 and a copy of each is enclosed.

1 of 6

Sheet 1 of 14

Form PTO-1449 (REV. 8-83)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

MAIL ROOM SEP 14 1990 PAT. & TRADEMARK OFF.

INFORMATION DISCLOSURE CITATION

(Use several sheets if necessary)

ATTY. DOCKET NO.	SERIAL NO.
MIT5088S	565,274
APPLICANT: James Raymond Davis, et al.	
FILING DATE: August 9, 1990	GROUP: 234

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		~~4697281~~		~~Harry M. O'Sullivan~~			

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

EP	"Synthetic speech for real time direction-giving," C.M. Schmandt et al., Digest of Technical Papers, International Conference on Consumer Electronics, Rosemont, Illinois, June 6-9, 1989.
EP	"Synthetic speech for real time direction giving," C.M. Schmandt et al., IEEE Transactions on Consumer Electronics, 35(3):649-653, August 1989
EP	"The Back Seat Driver: Real time spoken driving instructions," J.R. Davis et al. Proceedings of the IEEE Vehicle Navigation and Information Systems Conference, Toronto, Canada, September 1989

EXAMINER	DATE CONSIDERED
Edward Pipala	10/31/91

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Sheet 2 of 14

Form PTO-1449 (REV. 8-83)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. MIT5088S	SERIAL NO. 565,274
INFORMATION DISCLOSURE CITATION		APPLICANT James Raymond Davis et al.	
(Use several sheets if necessary)		FILING DATE August 9, 1990	GROUP 234

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

EP	"Back Seat Driver: Voice assisted automobile navigation" by J.R. Davis, Ph.D. Thesis, Massachusetts Institute of Technology, September, 1989.
EP	"CD-ROM Assisted Navigation Systems" by O. Ono et al., Digest of Technical Papers, IEEE International Conference on Consumer Electronics, Rosemont, Illinois, June 8-10, 1988.
EP	"Attention, intentions, and the structure of discourse" by B.J. Grosz and C.L. Sidner (Computational Linguistics, 12(3):175-204, 1986.

EXAMINER	DATE CONSIDERED
Edward Pipala	10/31/91

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[which composes] for accepting the current position from said location system and the route from said route finder, for consulting said map database, and for composing discourse including instructions and other messages [based on data from said location system, said route-finder, and said map database] for directing the driver to the destination from the current position,

P1 a speech generator functionally connected to said discourse generator [which generates] for generating speech from said discourse provided by said discourse generator, and

P1 voice apparatus functionally connected to said speech generator for communicating said speech provided by said speech generator to said driver.

In the Figures:

Please add the enclosed **Figs. 3-5.**

Remarks

Reexamination and reconsideration of the rejections are hereby requested for the following reasons.

The examiner has objected to the title for being not descriptive. In response, applicant has changed the title to "Automobile Navigation System Using Real Time Spoken Driving Instructions."

The examiner has objected to the drawings under 35 CFR 1.83(a) for not showing every feature of the invention specified in the claims. In a telephone interview, the examiner stated that simple block diagrams of the features amenable to illustration would suffice. In response, applicant has added **Figs. 3-5,** which illustrate the features claimed. No new matter has been added by this amendment.

The examiner has objected to the disclosure because of informalities. The typographical errors cited by the examiner have been corrected in the above amendments.

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The examiner has rejected claims 1-58 under 35 U.S.C. 112, second paragraph, as being indefinite. Claim 1 has been amended to more particularly point out the connections and interactions between the different elements of the invention, as required by the examiner.

The examiner has rejected claims 1-58 under 35 U.S.C. 102(e) as being anticipated by the Ph.D. thesis of J.R. Davis. During a telephone conversation with the examiner, the examiner stated that the reason for the rejection was that the title page of the thesis bears a submission date of August 4, 1989, more than one year before the filing date of the present application. August 4 is the date that the thesis was signed, and not the date on which the thesis became available to the public. M.I.T. does not generally catalog and shelve theses until several months after the official date of submission. Enclosed is a copy of the title page of the M.I.T. library's copy of the thesis, which bears a date of February 27, 1990. Therefore, the thesis did not become available to the public more than a year before the filing date of the present application, and is therefore not 102 art with respect to the present application.

In response to the examiner's request, copies of references which were included in the Information Disclosure Statement filed with the application which the applicant considers pertinent to the present invention as claimed and which the applicant would like to be considered and made of record are enclosed and included on a new PTO-1449.

It is respectfully submitted that the claims are now in condition for allowance, and it is requested that a Notice of Allowance be issued.

Please charge any fees in connection with this response to our Deposit Account No. 08-1721.

Respectfully Submitted,

Sam Pasternack

Sam Pasternack, Esq.
Reg. No. 29,576

Choate, Hall & Stewart
Exchange Place
53 State Street
Boston, MA 02109
(617) 227-5020

May 5, 1992

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on May 5, 1992

Sam Pasternack

EXHIBIT 3

IN THE UNITED STATES PATENT OFFICE

Applicant: J.R. Davis and C.M. Schmandt
Serial No.: 565,274
Filed: August 9, 1990
For: Automobile Navigation System

Art Unit: 2304
Examiner: E. Pipala

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Amendment

In response to the Office Action mailed November 8, 1991, please amend the application as follows:

In the Title:

Replace "Automobile Navigation System" with - - Automobile Navigation System Using Real Time Spoken Driving Instructions - -.

In the Specification:

Page 4, after line 12, insert:

- - **Fig. 3** is a schematic illustration of the map database.

Fig. 4 is a schematic illustration of the route finder.

Fig. 5 is a schematic illustration of the position sensor. - -

Page 11, line 5: replace "street" with - - streets - -.

Page 11, after line 19, insert the following new paragraph:

- - The map database is shown schematically in **Fig. 3**. In the preferred embodiment, the map database **14** includes, as its basis, a file **28** of segments and

nodes. File **28** may be an original file or may be adapted from a DIME file or a TIGER file by adding the above-described extensions. In addition, the map database **14** may include optional features **30**, as described above. - -

Page 16, after line 2, insert the following new paragraph:

- - The route finder is shown schematically in **Fig. 4**. In the preferred embodiment, the route finder **16** includes, as its basis, an algorithm **32.** Algorithm **32** may be, for example, an original algorithm based on a best-first search algorithm, the A* algorithm, or a modified A* algorithm. In preferred embodiments, the route finder is adapted to find the best route according to any one of three cost metrics **34**: distance, speed, simplicity. The route finder calculates a new route in the event of driver error or unforeseen circumstances, as indicated. - -

Page 17, after line 27, insert the following new paragraph:

- - The position sensor is shown schematically in **Fig. 5**. As indicated, it includes a displacement sensor **36** and a direction sensor **38**. - -

Page 25, line 17: replace "it" with - - is - -.

Page 25, line 30: replace "heaing" with - - hearing - -.

Page 34, line 16: replace "the" with - - to - -.

Page 35, line 7: replace "beable" with - - be able - -.

Page 38, line 15: replace "is" with - - it - -.

Page 39, line 6: replace "is" with - - in - -.

Page 40, line 16: replace "Give" with - - Given - -.

Page 44, line 2: replace "never" with - - ever - -.

In the Claims:

Claim 1 (Amended)

An automobile navigation system which [uses] produces spoken instructions to direct a driver of an automobile to a destination in real time comprising:

computing apparatus [adapted to run and coordinate] for running and coordinating system processes,

driver input means functionally connected to said computing apparatus [whereby the driver can enter] for entering data into said computing apparatus, said data including a desired destination,

a map database functionally connected to said computing apparatus which distinguishes between physical and legal connectivity,

~~position sensing apparatus installed in the~~ automobile and functionally connected to said computing apparatus for providing said computing apparatus data for determining the automobile's current position,

a location system functionally connected to said computing apparatus [which determines] for accepting data from said position sensing apparatus, for consulting said map database, and for determining the automobile's current position [on a map] relative to the map database [from data from the position sensing apparatus],

a route-finder functionally connected to said computing apparatus, [which] for accepting the desired destination from said driver input means and the current position from said location system, for consulting said map database, and [computes] for computing a route to the destination [from any current position],

a discourse generator functionally connected to said computing apparatus

[which composes] for accepting the current position from said location system and the route from said route finder, for consulting said map database, and for composing discourse including instructions and other messages [based on data from said location system, said route-finder, and said map database] for directing the driver to the destination from the current position,

a speech generator functionally connected to said discourse generator [which generates] for generating speech from said discourse provided by said discourse generator, and

voice apparatus functionally connected to said speech generator for communicating said speech provided by said speech generator to said driver.

In the Figures:

Please add the enclosed **Figs. 3-5**.

Remarks

Reexamination and reconsideration of the rejections are hereby requested for the following reasons.

The examiner has objected to the title for being not descriptive. In response, applicant has changed the title to "Automobile Navigation System Using Real Time Spoken Driving Instructions."

The examiner has objected to the drawings under 35 CFR 1.83(a) for not showing every feature of the invention specified in the claims. In a telephone interview, the examiner stated that simple block diagrams of the features amenable to illustration would suffice. In response, applicant has added **Figs. 3-5**, which illustrate the features claimed. No new matter has been added by this amendment.

The examiner has objected to the disclosure because of informalities. The typographical errors cited by the examiner have been corrected in the above amendments.

The examiner has rejected claims 1-58 under 35 U.S.C. 112, second paragraph, as being indefinite. Claim 1 has been amended to more particularly point out the connections and interactions between the different elements of the invention, as required by the examiner.

The examiner has rejected claims 1-58 under 35 U.S.C. 102(e) as being anticipated by the Ph.D. thesis of J.R. Davis. During a telephone conversation with the examiner, the examiner stated that the reason for the rejection was that the title page of the thesis bears a submission date of August 4, 1989, more than one year before the filing date of the present application. August 4 is the date that the thesis was signed, and not the date on which the thesis became available to the public. M.I.T. does not generally catalog and shelve theses until several months after the official date of submission. Enclosed is a copy of the title page of the M.I.T. library's copy of the thesis, which bears a date of February 27, 1990. Therefore, the thesis did not become available to the public more than a year before the filing date of the present application, and is therefore not 102 art with respect to the present application.

In response to the examiner's request, copies of references which were included in the Information Disclosure Statement filed with the application which the applicant considers pertinent to the present invention as claimed and which the applicant would like to be considered and made of record are enclosed and included on a new PTO-1449.

It is respectfully submitted that the claims are now in condition for allowance, and it is requested that a Notice of Allowance be issued.

Please charge any fees in connection with this response to our Deposit Account No. 03-1721.

Respectfully Submitted,

Sam Pasternack

Sam Pasternack, Esq.
Reg. No. 29,576

Choate, Hall & Stewart
Exchange Place
53 State Street
Boston, MA 02109
(617) 227-5020

May 5, 1992

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231. on May 5, 1992

Sam Pasternack

Back Seat Driver: voice assisted automobile navigation

by

James Raymond Davis

B.S.A.D., Massachusetts Institute of Technology (1977)

Submitted to the Media Arts and Sciences Section
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 1989

Signature of Author ....
Media Arts and Sciences Section
August 4, 1989

Certified by ....
Nicholas P. Negroponte
Professor of Media Technology
Thesis Supervisor

Accepted by ....
Stephen A. Benton
Chairman, Departmental Committee on Graduate Students

EXHIBIT 4

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF CHRISTOPHER M. SCHMANDT

I, Christopher M. Schmandt, state the following:

1. I am a named inventor on U.S. Patent No. 5,177,685, which is being asserted against Harman in this case.

2. I was an advisor of Dr. James R. Davis during the "Back Seat Driver" doctoral research. I currently am Principal Research Scientist at the MIT Media Lab.

3. Harman's Statement of Undisputed Facts ("SOUF") says "Schmandt testified that while Davis was working on his thesis, and even after he finished drafting it, Davis 'could print a copy [of it] whenever he wanted and give that to anybody that he wanted to.'" SOUF ¶ 5. However, Harman has mischaracterized my testimony by omitting clarifying answers that I gave in response to Harman's questions. See MIT 30(b)(6) deposition at 115:14-23 (Q: So you didn't mean to imply that the thesis was on a password protected computer in the Media Lab, that that excluded the possibility that anybody printed out and shared copies of the thesis? A: That limits the number of people who could print out and share copies of the thesis to approximately two. Q: How does it do that? A: Jim Davis and myself are the only ones who had access to the document); 116:23-117:7 (Q: Is there any other evidence that M.I.T. contends supports any steps that were taken to preserve the confidentiality of Mr. Davis' thesis paper or drafts thereof during the time period prior to August 9th of 1989? A: It's generally University policy, and M.I.T. is no exception, that drafts of documents such as thesis are not public. They are not to be distributed publicly).

4. The computer on which drafts of Jim's thesis were on a password-protected computer in a locked room accessible by a keypad with an entry code. MIT 30(b)(6) deposition at 113:15-21.

5. Harman says that "On July 31, 1989, Davis and Schmandt sent a copy of the completed thesis ('certified by Nicholas P. Negroponte,' the then Director of the MIT Media Lab) to a Mr.

Rittmueller, an NEC employee at the time." SOUF ¶ 6. I do not recall sending a copy of Jim's completed thesis to Phil Rittmueller on July 31, 1989 (or any time before August 9, 1989). I believe that Phil did not get a copy of Jim's thesis until after it was shelved in MIT's library.

6. Harman says "The copy of Davis' thesis sent to Rittmueller was not marked confidential in any way." SOUF ¶ 7. However, NEC was the sponsor of the Back Seat Driver research and as such, entitled to periodic reports on the progress of the research. NEC was also a licensee of this technology as a result of the sponsorship, and MIT and NEC understood that the underlying research work and internal document drafts were not publicly available and not to be distributed until the documents, like Jim's thesis, were finalized.

7. Harman says "By May 26, 1989, Davis was prepared to defend his thesis and invited the public to attend." SOUF ¶ 12. Jim actually defended his thesis in late summer of 1989, and he graduated in September 1989. While I do not remember the exact room in which the thesis defense took place, I do remember that the thesis defense did not take place in the room identified on the draft flyer, namely E15-283a of the Media Lab, because Jim defended his thesis in a larger room.

8. Harman says that "MIT had a policy forbidding secrecy and encouraging the free sharing of information in 1989." SOUF ¶ 13. MIT's policy does not absolutely forbid secrecy and encourage sharing of information before the information is ready to be shared. As an academic institution, MIT has ethical and integrity reasons for not publishing research or other findings before the information is finalized or verified. Until the thesis was shelved in the MIT library, the general public did not have access to Jim's thesis.

9. Harman says that "NEC was upset and unhappy that MIT's publicity of the Back Seat Driver had caused NEC to waste considerable time and effort only to lose any foreign patent

rights it may have had." SOUF ¶ 18. In fact, NEC was not upset and unhappy with MIT. NEC continued to sponsor the MIT Media Lab after the Back Seat Driver project was completed, and Phil Rittmueller continued to support the Media Lab's research.

10. In addition to the patent in this case, I am a named inventor on three other issued U.S. Patents and seven U.S. Patent applications. I understand that as an inventor I have a duty of candor and good faith in practice before the U.S. Patent Office, and that this duty requires me to provide relevant, non-cumulative information that is known to me to the Patent Examiner. In all of my patents and applications, I strive to meet or exceed these duties.

11. I understand that violations of the duty of candor and good faith can result in one or more of my patents or applications being unenforceable. I understand for someone to prove that one of my patents or applications is unenforceable, that person is required to prove that I withheld material information from the Patent Office or made material false statements to the Patent Office with an intent to deceive the Patent Office.

12. As an MIT research scientist and graduate student advisor, I am bound by strict ethical obligations relating to academic research, including not publishing someone else's work, not accepting a doctoral thesis that is not original and significant, and to generally be honest in stating research results or discoveries.

13. At no time during the prosecution of the '685 patent did I withhold information from my patent attorney, Bo Pasternack, or from the Patent Office that I thought was relevant to the patented invention. Additionally, if any information that is deemed to be relevant was withheld by me, I did not withhold that information with intent to deceive the Patent Office.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on February 8 and May 19, 2006 if asked by counsel for Harman.

Dated: May 23, 2007

Christopher M. Schmandt

EXHIBIT 5

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF JAMES R. DAVIS, PH.D.

I, James R. Davis, Ph.D., state the following:

1. I am an inventor on U.S. Patent 5,177,685, which is based on my Ph.D. research project called the "Back Seat Driver," which provided intelligent spoken instructions in an autonomous vehicle navigation system.

2. Harman says in its Statement of Undisputed Facts ("SUF") that I could have printed a draft of my thesis and given it to anyone I wanted. SUF, para. 5. Although I *could* have done it, it was not my normal practice to print copies of my draft thesis and give it to the general public. I am not aware of any evidence to suggest the contrary.

3. Harman says that "On July 31, 1989, Davis and Schmandt sent a copy of the completed thesis ('certified by Nicholas P. Negroponte,' then director of the MIT Media Lab) to a Mr. Rittmueller, an NEC employee at the time." SUF, para. 6. I believe Harman is wrong. I do not recall sending a copy of my thesis to Mr. Rittmueller before it was published.

4. Harman says that "Davis himself sent another copy of his thesis (unsigned by bearing an August 4, 1989 date for Davis' signature) to a Bell Labs employee, Lynn Streeter, without any confidentiality designation and without any restrictions on her use of it." SUF, para. 8. I do not recall sending a copy of my thesis to Lynn Streeter before I defended my thesis. Streeter was a professional and academic colleague who, if she had received a copy of my thesis from me, would have received my thesis with a view towards providing feedback and comments because she had done valuable and groundbreaking research in the field of direction-giving. As an academic, I would have considered Lynn bound by the ethical obligations regarding my thesis to not publish it as her own or otherwise freely distribute it, so no written "restrictions" were necessary.

5. Harman says that "In May 1989, after requesting from Davis a copy of 'any papers [Davis had] written about [the Back Seat Driver],' a University of Minnesota student responded to Davis that she could 'wait a couple weeks to see [Davis' T]hesis." SUF, para. 10. I do not believe I sent a copy of my thesis to this student in May 1989 or any time thereafter, and the email Harman points to does not show that I did. I earned my Ph.D. from MIT in September 1989, and my thesis was not ready for defense or distribution in May 1989.

6. Harman alleges that "By May 26, 1989, Davis was prepared to defend his thesis and invited the public to attend." SUF, para. 12. I was not prepared to defend my thesis on May 26, 1989. The "flyer" inviting the "public" to attend was a draft, as can be seen from the handwritten corrections and various typos in the flyer. I may have thought at one time that my thesis would be ready to defend on May 26, 1989, but in fact, it was not ready to defend until sometime later in the summer. My original goal was to graduate in June of 1989, which explains why I would have wanted to defend my thesis in May. However, Chris Schmandt and I recognized that the Back Seat Driver project needed some additional work before I could get my degree, and so we worked on additional prototypes over the summer of 1989. As a result, we were able to build and test an operational system by the end of the summer, which resulted in my thesis defense and graduation in the fall of 1989.

7. Harman says "When MIT submitted its Response to the First Office Action, MIT knew that Davis had actually distributed his thesis and that he did so more than once." SUF, para. 29. I believe that the only people who were given drafts or finalized versions of my thesis in 1989 were the actual members of my thesis committee or colleagues acting in an academic advisory capacity concerning the content of my thesis.

8. Harman states that "During prosecution of the '685 Patent, Davis knew that 50 subjects had used the Back Seat Driver between May 1, 1989 and July 31, 1989 and after Davis knew the Back Seat Driver would work." SUF, para. 57. Harman does not specify which version of the Back Seat Driver project was used by these test subjects. I believe Harman is referring to the "subjects" being used in an experiment to test a prototype of the system. For the driving experiments we conducted with undergraduate students, either Chris or I would ride along in the vehicle to observe the driver's performance and evaluate the user interface. Under the experiment's protocol, one of us was always in the car for test drives. This was required by the MIT Committee of the Use of Humans as Experimental Subjects. Contrary to what Harman says, although Chris and I were confident that the Back Seat Driver would work by June of 1989, we needed to continue field trials to ensure that the system was safe, effective, durable and repeatable.

9. Harman states that "During prosecution of the '685 Patent, Davis knew that he had continued to use the Back Seat Driver with 50 subjects after he knew the invention would work." SUF, para. 58. Harman mischaracterizes my testimony on this point. I did not testify that 50 drivers used the Back Seat Driver after I "knew the invention would work." Also, the passage from my testimony relied upon by Harman was clarified a few moments later: "Q: Did you continue to use the working "Back Seat Driver" with other people around the Boston area between June of '89, which you say is when you knew it would work, and August of '89, when you signed your thesis paper? A: First of all, I think what I testified is that by June of '89, I was confident that the system would work.). Although the subjects drove a car equipped with the Back Seat Driver, the drivers were generally not shown how the Back Seat Driver worked. Their

exposure to the system was limited to entering a destination and driving the car according to the supplied directions.

10. I understand that Harman is claiming that I committed inequitable conduct or fraud on the Patent Office in obtaining my patent by withholding material information or making materially false statements to the Patent Office with an intent to deceive the Examiner. I understand that inventors and their attorneys are bound by a duty of good faith and candor in dealing with the Patent Office to be truthful and honest.

11. I believe that everything I said to the Patent Office was true, and that I gave the Patent Office the non-duplicative and relevant information that I had. I believe that everything in my thesis is true and is not misleading. I have never intended to deceive the Patent Office about my patent or any other patents, and I believe that I met or exceeded my duties to the Patent Office.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on February 16, 2006 if asked by counsel for Harman.

Dated: May 23, 2007

James R. Davis, Ph.D.

EXHIBIT 6

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF SAM "BO" PASTERNACK, PH.D.

I, Sam "Bo" Pasternack, state the following:

1. I am a partner at the law firm of Choate Hall & Stewart.

2. I prosecuted U.S. Patent No. 5,177,685 on behalf of my client, the Massachusetts Institute of Technology ("MIT").

3. I am and have been a member in good standing of the bar of the United States District Court for the District of Massachusetts ("this Court") since 1978.

4. I have been registered to practice before the U.S. Patent and Trademark Office ("the Patent Office") since 1979.

5. In my career, I have prosecuted approximately 1,000 patents. I have never been found to have committed "inequitable conduct" in the prosecution of patents, and no client of mine has, to my knowledge, ever been sanctioned for my prosecution of patents.

6. Harman says that "In its Response to the First Office Action, MIT did not challenge the materiality of Davis' thesis or the Examiner's determination that the thesis anticipated each claim." SOF ¶ 24. In fact, MIT challenged the materiality of the thesis on its face because the thesis was not publicly available more than one year before the filing date of the '685 patent. MIT told the Examiner that "the thesis did not become available to the public more than a year before the filing date of the present application, and is therefore not 102 art with respect to the present application." Because the thesis was not "publicly available," the thesis was not "material" nor could it "anticipate" each claim of the '685 patent.

7. Harman's Statement of Undisputed Facts includes the statement that "MIT expressly acknowledged to the PTO that it clearly understood the Examiner's reasons for rejection." SOF ¶ 23. To the contrary, nowhere in the May 5, 1992 Office Action Response did MIT "expressly acknowledge" what Harman is claiming. Harman makes it sound like MIT conceded that Jim

Davis' Ph.D. thesis anticipated the '685 patent. In fact, MIT did not concede that point and further illustrated why the thesis was not anticipating (and not material).

8. Harman states that "MIT led the PTO to believe that the only access to Davis' thesis was through the MIT library" by referring to two sentences from the May 5, 1992 Office Action Response. SOF ¶ 27. The first sentence, "August 4, 1989 is the data [*sic*] [that] the thesis was signed, and not the date on which the thesis became available to the public," is true. The second sentence, "M.I.T. does not generally catalog and shelve theses until several months after the official date of submission," is also, to the best of my knowledge, true. These two sentences are not misleading.

9. Harman says "When MIT submitted its Response to the First Office Action, MIT knew that Davis had actually distributed his thesis and that he did so more than once." SOF ¶ 29. Harman's statement is misleading because it does not specify a date on which Jim Davis allegedly "actually distributed his thesis." Moreover, it suggests wrongly that any distribution of the thesis before the critical date would be a patentability bar. If Jim Davis distributed his thesis after the critical date, then his thesis is not material to patentability. If there was limited distribution before the bar date to a close group of colleagues, it would not be, in my opinion, a "publication." I was not aware at the time the Response to the Office Action was filed, nor am I informed today, that Davis' thesis was publicly distributed before the critical date.

10. Harman says "When MIT submitted its Response to the First Office Action, MIT knew that Davis publicly defended his thesis." SOF ¶ 30. Harman's statement is misleading. Harman does not specify a date on which Jim Davis publicly defended his thesis and particularly, whether the thesis defense occurred prior to the critical date. Moreover, I am of the opinion that a limited

public thesis defense would not, in and of itself, be a bar to patentability. In any event, I did not withhold any information from the Patent Office with the intent to deceive it.

11. Harman says that "MIT never told the PTO that it reduced to practice the sole independent claim and 22 dependent claims 'at least as early as June of 1989.'" SOF ¶ 47. Harman also says that "MIT never told the PTO that is [*sic*] reduce to practice 23 more dependent claims 'at least as early as August 4, 1989.'" SOF ¶ 48. However, the rules of patent practice do not generally require patent applicants to disclose the date on which an invention was reduced to practice to obtain a patent. *See* MPEP § 2138.05 ("Thus the inventor need not provide evidence of either conception or reduction to practice when relying on the content of the patent application").

12. Harman states that "MIT only disclosed to the PTO that 'An actual working prototype of the Back Seat Driver has been implemented. It has successfully guided drivers unfamiliar with Cambridge, Mass. to their destinations. It is easy to foresee a practical implementation in the future." SOF ¶ 54. However, MIT submitted four references to the Patent Office relating to the Back Seat Driver and authored by Jim Davis and/or Chris Schmandt, all of which appear on the face of the patent, and all of which refer to field trials of the Back Seat Driver or the fact that the Back Seat Driver was working. Thus, Harman's statement that "MIT only disclosed" one sentence is factually incorrect.

13. Harman states that "MIT's prosecuting attorney testified that if '[the Back Seat Driver] was in use more than one year prior to the filing date of the ['685] application, then [that use] would have been relevant to the PTO." SOF ¶ 55. However, counsel for Harman did not ask me whether test drives or field trials of the Back Seat Driver prototypes constituted "use" or "public use" of the invention, and I did not concede that any test drives or field trials in fact constituted

use or public use. At best, the passage quoted by Harman is out of context and implies that I conceded that the test drives or field trials in fact constituted use or public use, which I did not.

14. Harman states that "MIT's prosecuting attorney made no effort to investigate the public uses of the 'prototypes' disclosed in the specification. Ex. 12 79:17-19 ('Did you specifically search for documents related to the field trials? A. No.')." SOF ¶ 56. Harman's statement and the quotation of my deposition testimony to support the statement is misleading. The passage cited by Harman occurred during a line of questioning about production of documents from my files in connection with this litigation (not with prosecution of the '685 patent). The question from Harman's counsel was not whether I investigated field trials prior to filing the application for the '685 patent, and thus Harman's statement and support is misleading.

15. During the prosecution of the application that led to the '685 patent, as is true today, I was aware of the duty of candor in dealing with the Patent Office, and I was aware of the consequences of failing to comply with the duty of candor.

16. It is my standard practice to comply with my duty of candor to the Patent Office by submitting or citing to the Patent Office all information and prior art that I believe would be deemed material to the patentability of the claims or that I believe a reasonable patent examiner would deem relevant of which I am aware and or provided to me by the inventors or representatives of the assignee. I did not deviate from my standard practice during the prosecution of the '685 patent or thereafter.

17. At no time during the prosecution of the '685 patent did I take any actions with intent to deceive the Patent Office in connection with the '685 patent.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on June 1, 2006 if asked by counsel for Harman.

Dated: May 21, 2007

Sam Pasternack

Sam "Bo" Pasternack, Ph.D., Esq.

EXHIBIT 7

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF LYNN A. STREETER, PH.D.

I, Lynn A. Streeter, state the following:

1. I am President of Pearson Knowledge Technologies. I have been retained as a testifying expert in this case, and have previously submitted an expert report and been deposed in this litigation.

2. I was aware of the "Back Seat Driver" doctoral research being undertaken by James R. Davis in the 1988-1990 timeframe from my personal contact with one of my colleagues at Bellcore, Mike Lesk, and with Jim Davis.

3. Mike Lesk was on Davis' thesis committee. Sometime after Davis defended and finalized his thesis, Mike Lesk or Jim Davis provided me with a copy of Davis' thesis. As I testified during my deposition, I do not recall the precise date on which I actually received a draft of Jim Davis' thesis. I understood at the time that Davis' thesis was not a public document and that I was provided a copy on the understanding that I would not distribute or disseminate the document until after it became publicly available.

4. Harman's Statement of Undisputed Facts, at paragraph 8 says "Davis sent another copy of his thesis (unsigned but bearing an August 4, 1989 date for Davis' signature) to a Bellcore employee, Lynn Streeter, without any confidentiality designation and without any restriction on her use of it...(Dr. Streeter then forwarded Davis' Thesis to third parties)." Harman does not say when I received the thesis draft, nor when I allegedly forwarded Jim's thesis to any third parties. I do not believe the copy of the thesis I received was a priority or rush copy such that I would have gotten a copy before Jim Davis defended his thesis or before the thesis was public.

5. I understand that Harman points to a note produced from my files to suggest that I sent Davis' thesis to a third party, Karen Lochbaum, without any kind of confidentiality. This document bears a Bates number of STREETER00052. This document does not have a date on it.

I believe that this document was created after Davis' thesis became publicly available. I do not believe that if I sent a copy to Karen Lochbaum that I did so immediately after receiving my copy of it or on an otherwise urgent basis. More than likely, I found the thesis while cleaning my office sometime later, and thought Karen might be interested in seeing the thesis since she was a graduate student at Harvard studying dialog issues.

6. Harman further claims that I received the thesis "the day it was published" (Statement of Undisputed Facts, paragraph 9). However, as I testified during my deposition, I do not recall the exact date on which I received the thesis and do not believe that I received a copy of the thesis before Jim had defended it. I also did not testify that I received Jim's thesis "the day it was published," what I said was I thought I got a copy "about the same time" as Mike Lesk went to Cambridge for the thesis defense. I also do not believe that I received a copy of Davis' thesis before Mike Lesk did, who was on Jim's thesis committee.

7. I understood at the time that in the academic environment, research results and theses drafts are sometimes circulated among close groups of colleagues for comment or feedback, but that these results and drafts were not to be published by others without the agreement of the researcher or author.

8. I believe that Davis and Schmandt considered me a research colleague and trusted confidante based on my earlier research and collaboration with them. I understood that communications between myself and Davis or Schmandt were considered private communications that were not public or for public distribution.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on September 13, 2006 if asked by counsel for Harman.

Dated: May 22, 2007

Lynn A. Streeter, Ph.D.

EXHIBIT 8

Excerpts from the:

May 19, 2006
30(b)(6) Deposition of
MIT through Christopher Schmandt

Volume: I

Pages : 1 - 140

Exhibits: 90 - 96

UNITED STATES DISTRICT COURT

DISTRICT OF MASSACHUSETTS

CIVIL ACTION NO. 05-10990-DPW

\- -

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiff,

v.

HARMAN INTERNATIONAL INDUSTRIES INCORPORATED,

Defendant.

\- -

CONFIDENTIAL

VIDEOTAPED 30(b)(6)DEPOSITION OF M.I.T.

through CHRISTOPHER SCHMANDT

Friday, May 19, 2006, 2006, 9:40 a.m.

Proskauer Rose LLP

One International Place

Boston, Massachusetts

Reporter: Rosemary F. Grogan, CSR, RPR

LegaLink Boston, a Merrill Company

APPEARANCES:

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BY: CRAIG D. LEAVELL, ESQUIRE

Also present:

Jason Moschella, Videographer

INDEX

EXHIBITS

(Original Exhibits Attached to Original Transcript)

09:34:12 THE VIDEOGRAPHER: This is the beginning of
09:39:44 videocassette No. 1 in the deposition of the
09:39:47 Massachusetts Institute of Technology by and
09:39:50 through Christopher Schmandt in the matter of
09:39:53 M.I.T., plaintiff, versus Harman International
09:39:56 Industries Incorporated, defendant, in the United
09:40:00 States District Court, District of Massachusetts,
09:40:04 Civil Action No. 05-10990-DPW.

09:40:11 Today is May 19, 2006. The time is 9:40 a.m.
09:40:15 My name is Jason Moschella. I'm a certified legal
09:40:20 video specialist and a notary public contracted by
09:40:23 LegaLink Boston. This deposition is taking place
09:40:26 today at the offices of Proskauer Rose LLP, One
09:40:30 International Place, Boston, Massachusetts and was
09:40:33 noticed by Kirkland & Ellis.

09:40:35 At this time counsel will please identify
09:40:38 yourselves and the court reporter will administer
09:40:40 the oath.

09:40:42 MR. LEAVELL: This is Craig Leavell from
09:40:42 Kirkland & Ellis on behalf of Harman International.

09:40:44 MS. MOTTLEY: This is Kimberly Mottley of
09:40:46 Proskauer Rose on behalf of M.I.T.

CHRISTOPHER SCHMANDT, having been satisfactorily identified by the production of a driver's license, and duly sworn by the Notary Public, was examined and testified as follows:

EXAMINATION BY MR. LEAVELL:

Q. Good morning, sir.
A. Good morning.
MR. LEAVELL: I'm going to ask the court reporter to mark the next exhibit as Exhibit 90.
(Exhibit 90 Marked for Identification)
BY MR. LEAVELL:
Q. Mr. Schmandt, have you seen a copy of Exhibit 90 prior to today, which is the Notice of Harman's First Rule 30(b)(6) Deposition of MIT, for the record?
A. Yes, I have.
Q. And you've had a chance to consult with counsel for M.I.T. about the scope of today's deposition; is that correct?
A. Yes, I have.
MS. MOTTLEY: I can represent for the record, Craig, that Mr. Schmandt is ready to testify on

thesis paper or drafts of his thesis paper at any time prior to August 9th, 1989?

A. Yes.

Q. What is that evidence?

A. The thesis was received at the M.I.T. library on February 27, 1990. The date is stamped on the thesis and has been verified with library. That means the thesis was not turned over to the library for public dissemination until February 27, 1990.

It was not shelved until September 1990, nor was it cataloged until that time. That's normal M.I.T. library delay.

Q. Well, that's the final version. My question was directed to drafts of the thesis.

Is there any evidence that Mr. Davis took any steps to protect the confidentiality of the draft thesis paper or the thesis paper itself prior to August 9th of 1989?

A. Certainly, the drafts of the thesis were on a password protected computer. The computer itself physically was in a room that had a keypad combination.

Q. And where was that computer at?

A. M.I.T. Media Lab, third floor.

Q. So if Mr. Davis wanted to work on his thesis

13:52:33 in use today; plus it is my knowledge as somebody who
13:52:40 was in charge of some graduate thesis work at the Media
13:52:45 Lab and done at that time thesis which was only done in
13:52:47 LaText as well as most of our publications.
13:52:55 Q. So the editing that Miss Quad (P), Mr. Bender,
13:53:01 Mr. Dresser and Miss Druhecker did, all took place at
13:53:05 the Media Lab at this one computer?
13:53:07 A. They presumably would have edited hard copy.
13:53:13 Q. So there were copies of the thesis that
13:53:15 existed other than on that password protected computer,
13:53:20 correct?
13:53:22 A. Jim could print a copy whenever he wanted and
13:53:24 give that to anybody that he wanted to.
13:53:28 Q. So you didn't mean to imply the fact that the
13:53:30 thesis was on a password protected computer in the Media
13:53:34 Lab, that that excluded the possibility that anybody
13:53:38 printed out and shared copies of the thesis?
13:53:40 A. That limits the number of people who could
13:53:42 print out and share copies of the thesis to
13:53:45 approximately two.
13:53:46 Q. How does it do that?
13:53:47 A. Jim Davis and myself are the ones who had
13:53:49 access to the document.
13:53:50 Q. All right. But Jim Davis could have printed it

out and shared it with anybody he wanted, right?

A. He could have. Like I said, there were two people that could have done that; Jim Davis and myself.

Q. Who did you talk to to determine when the thesis paper was shelved and cataloged in the M.I.T. library?

A. Somebody at the M.I.T. library. I forget her name.

Q. What was she -- was she at the reference desk or what department? How did you find her?

A. I don't actually know. Karin Rivard got the information from her.

Q. Who is that?

MS. MOTTLEY: Counsel.

BY MR. LEAVELL:

Q. So counsel talked to somebody at the M.I.T. library and counsel told you that that's when the thesis was shelved and cataloged?

A. This is M.I.T. counsel. I know when the thesis was received at the M.I.T. library intrinsically because that's the date that's stamped on it. You'll see it on your copy there on the bottom center.

Q. Is there any other evidence that M.I.T. contends supports any steps that were taken to preserve

the confidentiality of Mr. Davis' thesis paper or drafts thereof during the time period prior to August 9th of 1989?

A. It's generally University policy, and M.I.T. is no exception, that drafts of documents such as thesis are not public. They are not to be distributed publicly.

Q. Anything else?

A. No.

Q. Is there any evidence that the M.I.T. Media Laboratory Speech Group reports that are identified in topic No. 2 were the subject of any steps to preserve their confidentiality during the time period of August 9, 1989?

A. They weren't published.

Q. Anything else?

A. In order for them to distribute it, I probably would have had to know about it.

Q. What do you mean by, Probably Would Have Known about it?

A. The documents were stored in a closest. Somebody could have come in and stolen them. The normal operating procedure if somebody wanted a document -- and first of all they, would have to know they existed which

CORRECTIONS TO 30 (b)(6) DEPOSITION TRANSCRIPT
OF M.I.T. through CHRISTOPHER M. SCHMANDT
May 19, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
14	24	Change "defendant" to "dependent"	Transcription error
18	10	Change "Digestive" to "Digest of"	Transcription error
53	18	Change "best search" to "best first search"	Transcription error
64	22	Change "GP" to "GPS"	Transcription error
77	15	Change "name" to "names"	Transcription error
114	15	Change "LaText" to "LaTex"	Transcription error
114	20	Change "LaText" to "LaTex"	Transcription error
114	21	Change "LaText" to "LaTex"	Transcription error
115	4	Change "LaText" to "LaTex"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Ch ar

Christopher M. Schmandt

EXHIBIT 9

Excerpts from the:

November 21, 2006
Deposition of
Phillip Rittmueller

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF	)	
TECHNOLOGY,	)	
Plaintiff,	)	Civil Action
vs.	)	No. 05-10990 DPW
HARMAN INTERNATIONAL	)	
INDUSTRIES, INCORPORATED,	)	
Defendant.	)	

The videotaped deposition of PHILIP RITTMUELLER, called for examination, taken pursuant to the Federal Rules of Civil Procedure of the United States District Courts pertaining to the taking of depositions, taken before KRISTIN C. BRAJKOVICH, CSR No. 084-3810, a Certified Shorthand Reporter of said state, at Suite 5400, 200 East Randolph Street, Chicago, Illinois, on the 21st day of November, A.D. 2006, at 8:59 a.m.

COPY

PRESENT:

PROSKAUER ROSE, LLP,
(One International Place,
Boston Massachusetts 02110-2600,
617.526.9779) by:
MS. KIMBERLY A. MOTTLEY,
appeared on behalf of the Plaintiff;

KIRKLAND & ELLIS, LLP,
(200 East Randolph Drive, Suite 5400,
Chicago, Illinois 60601,
312.469.7019) by:
MR. JAMAL EDWARDS,
appeared on behalf of the Defendant.

ALSO PRESENT:
MR. JOE BURKE, Videographer,
Esquire Deposition Services

REPORTED BY: KRISTIN C. BRAJKOVICH, C.S.R.
CERTIFICATE NO. 084-3810.

THE VIDEOGRAPHER: We are going on the video record at 8:59 a.m. My name is Joe Burke, and I am a legal videographer with Esquire Deposition Services. Our address is 155 North Wacker Drive, Chicago, Illinois. The court reporter today is Kristin Brajkovich of Esquire Deposition Services.

Here begins the videotaped deposition of Philip Rittmueller taking place in Chicago, Illinois. Today's date is November 21, 2006. This deposition is being taken in the matter of Massachusetts Institute of Technology versus Harman International, et al., in the United States District Court, Northern District of Illinois, Eastern Division.

Will counsel please state their names for the record.

MR. EDWARDS: Jamal Edwards, counsel for Harman.

MS. MOTTLEY: Kimberly Mottley from Proskauer Rose, counsel for MIT and the witness.

THE VIDEOGRAPHER: Will the reporter now swear in the witness, please.

(WHEREUPON, the witness was duly sworn.)

PHILIP RITTMUELLER,
called as a witness herein, having been first duly sworn, was examined and testified as follows:

EXAMINATION

BY MR. EDWARDS:

Q. Good morning, Mr. Rittmueller. My name is Jamal Edwards. I am with the law firm of Kirkland & Ellis LLP, and I am counsel for Harman International. How are you today?

A. I'm fine. Thank you.

Q. Good. I'm going to start with some background questions.

Would you please state your full name for the record.

A. My name is Philip Rittmueller.

Q. Do you have a middle name?

A. Yes. Howard. Usually use the initial H.

Q. And what is your current address, Mr. Rittmueller?

A. Current address is 36 W 698 Wild Rose Road, St. Charles, Illinois 60174.

Q. And how long have you lived in the Chicago area?

rights to the work involving the Back Seat Driver?
A. Not specifically.
Q. Do you recall whether NEC had any expectation concerning patent rights in the Back Seat Driver?
A. Just --
MS. MOTTLEY: Objection, vague.
Go ahead. You can answer.
BY THE WITNESS:
A. The typical standard MIT policy for either being a member of a consortia or doing directed research or whatever, whatever their various levels of relationships are. They have got standard policies for rights that go along with that, so that was the only expectation.
BY MR. EDWARDS:
Q. I appreciate that. So what you are telling me is that NEC had no other expectations concerning patent rights other than what was provided under MIT's standard policy?
A. Correct.
Q. Did you ever attend any conferences involving navigation system technology, Mr. Rittmueller?

Q. Do you think Jim Davis understood that?
A. Uh-huh.
Q. Did you-all discuss that?
A. I don't recall.
Q. Do you recall how long it took for them to get the database and put it in the car?
A. No, I don't.
Q. Do you recall ever seeing the database -- strike that.
Do you recall ever seeing the Back Seat Driver function with the database in the car?
A. I don't remember that.
Q. When did you first see Jim Davis' thesis?
A. I got it sometime after it was out and I visited MIT.
Q. "Sometime after it was out," what do you mean by that?
A. Well, when it was -- after it was available.
Q. After it was available to whom?
A. After he finished it.
Q. Did you ever see it before he finished it?

A. No.
Q. Did you ever see drafts of the thesis before he finished it?
A. I don't recall. I don't believe so.
Q. Do you recall discussing the thesis with anybody before he finished it?
A. No.
Q. Were you aware that he was doing a thesis?
A. Oh, yeah. It is for his Ph.D.
Q. Were you aware of what the thesis was about?
A. Yeah.
Q. Did you see any presentations about the thesis?
A. No. I mean, not the thesis per se. We had -- we were monitoring the project and we had quarterly reports and so on like that but not the thesis per se.
Q. During those quarterly reports, were there any discussions about the thesis?
A. No, not that I recall.
Q. Do you recall being told anything about the status of the thesis during the quarterly

Q. Do you recall whether you received parts of the thesis?
A. No. I would have copied it.
Q. You would have copied what?
A. Taken the full thesis and copied some section of it for some reason.
Q. And do you recall whether you received this before or after Mr. Davis finished his thesis?
A. This would have been after.
Q. And how do you know that?
A. Because I did not receive a copy before.
Q. And how do you know that?
A. I have no idea other than that I did not receive one before.
Q. Okay. Let's -- whenever you are ready, we can turn to the next document.
A. Okay.
Q. You might have shifted the order of things.
A. I'm sorry.
Q. So let's see.
MS. MOTTLEY: Right now we are looking at this stapled packet among this clipped packet.
BY THE WITNESS:

A. Yes, sir.
Q. Do you recall receiving this document?
A. Yes.
Q. Do you see the date on the document as 31 July 1989?
A. I see the date on the document.
Q. Do you have any reason to believe that you did not receive this document on that date?
A. I did not receive it then.
Q. Do you recall when you received it?
A. I received it sometime after.
Q. Sometime after? How much later?
A. I don't know exactly. It was probably sometime in the fall after the thesis had been completed. When this one was written, the thesis wasn't completed. This is the final report.
Q. Uh-huh. And did you receive the quarterly reports after the thesis was completed?
MS. MOTTLEY: Objection, vague as to which quarterly reports.
BY MR. EDWARDS:
Q. Any of them, including -- let's start with Rittmueller 7, which is the Back Seat Driver, Quarterly Report, dated March 5, 1990.

You received that one after the thesis was completed?
A. I don't know when I received them.
Q. What was the -- do you recall the procedure for MIT's transmission of these quarterly reports?
MS. MOTTLEY: Objection, assumes facts not in evidence.
BY THE WITNESS:
A. No, I don't remember the method.
BY MR. EDWARDS:
Q. Do you recall if there was a procedure?
A. I don't know that there was a procedure.
THE VIDEOGRAPHER: I need to change tapes in a minute.
MR. EDWARDS: Take a break.
MS. MOTTLEY: Sure.
THE VIDEOGRAPHER: Off the video record at 11:50.
(WHEREUPON, a recess was had.)
THE VIDEOGRAPHER: We are back on the video record at 11:58 with Tape No. 3.
BY MR. EDWARDS:
Q. Before we broke, we were talking about

Rittmueller 9 or RITT 9 which is the Back Seat Driver report dated July 31, 1989. Do you have that in front of you?
A. Yes, sir.
Q. I believe it was your testimony that you received this report after the thesis was submitted; is that correct?
A. It was all put together like this.
Q. Are you sure about that?
A. Positive.
Q. Do you see on -- since we combined the thesis with this paper, do you see the thesis which begins on Rittmueller 187?
A. Yes.
Q. Do you see it is not signed by the author?
A. Yes.
Q. Do you see that it is not signed by the chair of the department?
A. Yes.
Q. Do you see that the only signature on the document dated September 1989 is that of Nicholas Negroponte?
A. Yes.

Q. Do you understand that after Mr. Davis completed his thesis, that he signed it?
A. I would assume so.
Q. Do you understand that the copy that was made available to the public in the library was signed by Mr. Davis?
A. I don't know that.
Q. Have you ever seen a copy of the thesis that is available through MIT's library?
A. No.
Q. Have you ever seen a copy that was signed by Mr. Davis?
A. No.
Q. Are you sure you got this after Mr. Davis submitted the thesis?
A. I'm almost -- I'm sure I got this after he submitted the thesis.
Q. Do you have any idea why he didn't sign it?
A. No.
Q. And how are you sure that you got this after the thesis?
A. I just remember that it was -- I was there, and there was talk about it being in the

library or being wherever it goes to someplace, shelving it or whatever they call it, and I asked to see if I could get a copy at that particular time and I got this one.

Q. Would it surprise you to know that the copy that is in the library has Jim Davis' signature on it?

A. No. I would assume it would.

Q. But you would agree with me the copy that you have, doesn't have --

A. Does not have it, correct.

Q. So you would agree with me, they did not get you a copy of what was on the shelf at the library?

A. Yes, they did not.

Q. And do you recall now whether it was NEC and MIT's practice to exchange these quarterly reports after the thesis had been completed?

A. There was not specific timing set up for quarterly reports. They maybe happened at visits. I mean, they had to prepare them, but as far as exchanging them, there was not specific timing set up.

Q. You understand that you are testifying

today under oath?
A. Yes, sir.
Q. And do you understand that if we find inaccuracies later, we will point them out at trial if you are subpoenaed to testify at trial?
A. I understand that.
Q. Do you understand that testifying falsely under oath is a crime called perjury?
A. I understand that.
Q. And it is your testimony today that you did not receive this until after the thesis was submitted to the library?
A. Yes, that's my recollection.
Q. And do you recall receiving any other copies of this final report prior to the thesis being submitted?
A. I don't recall any other.
Q. Do you recall receiving any other copies of Mr. Davis' thesis prior to it being submitted to the library?
A. No.
Q. Let's look at the quarterly report on page -- the second page, which is Rittmueller 173.
A. Yes.

regular basis, but the detail and level of subjects that you go into varies extensively.

Q. When you have hired patent counsel before, if the patent application was rejected, would your patent counsel let you know?

A. If it was one of ours.

Q. What if it was one that you were paying for?

MS. MOTTLEY: Objection, hypothetical, calls for speculation.

BY THE WITNESS:

A. I don't know the answer to that.

BY MR. EDWARDS:

Q. NEC was paying for the prosecution of the MIT Back Seat Driver patent; isn't that correct?

A. No, we weren't. We didn't pay for it.

Q. You didn't have an agreement to pay for --

A. No.

Q. -- the patent prosecution?

A. No. MIT pays for the U.S. application. It is only the foreign applications where the sponsor pays.

Q. So what else did NEC pay for out of the $200,000?

A. It was for the research.

Q. For the research?

A. Yeah. And the research time and doing the research, sharing the research.

Q. Do you recall whether NEC expected to get a license to any U.S. patents that resulted from the research?

A. That's part of that MIT standard policy.

Q. And do you recall whether the license NEC was to receive was exclusive or not?

A. It was nonexclusive.

Q. And your counsel wouldn't let you know if a patent that you were to receive a nonexclusive license to had been rejected?

A. I don't know.

Q. You don't know?

A. No.

Q. So did you communicate at all with your outside patent counsel concerning the MIT patent case?

A. I did not have -- I did not have discussions on that.

as to why you referred to the figures as weak?
A. Usually figures that I have had from my past experience have been more detailed.
Q. Do you recall seeing any of these figures before MIT submitted its patent application?
And I'm referring, just so you know and if you want to look, to Figures 1 and Figures 2 which follow, 929 and 931.
A. I don't know if they were figures in the thesis or not. I'm not sure. I don't recall -- I don't recall these from previous, but I don't say they don't exist.
MS. MOTTLEY: Did you want to mark that as an exhibit?
MR. EDWARDS: I did.
MS. MOTTLEY: Oh, you did mark it. That was Exhibit 21?
MR. EDWARDS: Yeah, 21.
MS. MOTTLEY: That goes in the stack and then he can give them all to her at the end.
BY MR. EDWARDS:
Q. Do you recall executing a confidentiality agreement with NEC -- I'm sorry --

with MIT?
A. No, I don't.
Q. Do you recall having any discussions with MIT concerning the confidentiality of the Back Seat Driver?
A. Not -- I mean, typically -- typically, shared research is held, I'll say, close to the vest.
Q. What does "close to the vest" mean?
A. Well, you don't go out and tell a whole bunch of people or tell people about it. You keep it within the company, and MIT keeps it within MIT.
Q. Did you have any documentation memorializing that understanding?
A. Nope.
Q. And in the case of work -- joint work being developed between NEC and other parties, did you ever execute confidentiality agreements?
A. Only if it is like a third-party company or a consulting firm or something like that.
Q. You would agree that MIT is a third party?
A. Yes, but we don't have nondisclosures with our outside patent counsel or our law firm or

our accountants and so on. That is given. You understand that.

Q. Right. But you would agree that MIT is not a law firm?

A. That's correct.

Q. MIT is an educational institution?

A. Yes.

Q. Do you understand the general policy of educational institutions, which is to make the information available to the public?

MS. MOTTLEY: Objection to the characterization and calls for speculation.

BY MR. EDWARDS:

Q. Would you disagree that educational institutions like MIT typically make their information available to the public?

MS. MOTTLEY: Objection, vague.

You can answer.

BY THE WITNESS:

A. Well, that is one of the things they do, but they also end up having DARPA contracts and they also end up having directed research projects, and there is a continuum of confidentiality, if that's what you're talking about.

BY MR. EDWARDS:

Q. And if there was such confidentiality, it would be in the contract, wouldn't it?

A. Not necessarily.

Q. If, for example, NEC decided to disclose information MIT thought was confidential, what do you believe MIT would have been able to do about it without an agreement?

MS. MOTTLEY: Objection, hypothetical, calls for speculation.

You can answer.

BY THE WITNESS:

A. Repeat the question again.

BY MR. EDWARDS:

Q. Let's take it in chunks. You agree that you have already testified that you did not have, on behalf of NEC, a confidentiality agreement?

A. I don't recall one, and I don't believe I ever executed one.

Q. With MIT?

A. Correct.

Q. Do you understand -- strike that.

Did you have any understanding that the information that you were receiving from MIT was

confidential?

MS. MOTTLEY: Objection, vague.

BY THE WITNESS:

A. Confidential -- confidential-ish, closely held-ish, that's how we considered it.

BY MR. EDWARDS:

Q. But not confidential?

MS. MOTTLEY: Objection.

BY THE WITNESS:

A. Not as described in things like protective orders.

BY MR. EDWARDS:

Q. Or as described in things like confidentiality agreements that two parties sign?

A. Correct.

Q. If you had decided to share MIT's information with a third party, do you believe that MIT would have had any recourse against NEC?

A. Any direct recourse?

Q. Yeah.

A. Probably not.

Q. So you would agree that you were -- would have been within your rights to share the information with third parties?

MS. MOTTLEY: Objection, mischaracterization.
You can answer.
THE WITNESS: I suppose.
BY MR. EDWARDS:
Q. Did MIT ever expressly tell you not to share the information that you received concerning the Back Seat Driver with any third parties?
A. Not that I can recall.
Q. Did you have a confidentiality agreement with your PR firm?
A. Yes.
Q. Did it cover the Back Seat Driver?
A. It covered everything that we talked about.
Q. And that's because you guys have a general retention agreement?
A. Yes.
Q. Did MIT know that?
A. I don't know.
Q. Did MIT ever ask?
A. No.
Q. Did you ever tell MIT that you were sharing your information with your PR firm?
A. I don't recall one way or the other.

Q. Do you recall being told to keep anything confidential when you rode around Boston with the Back Seat Driver prototype in the car?
A. I don't recall that.
Q. Do you recall MIT telling anyone else that was riding in the car to keep anything they saw confidential concerning the Back Seat Driver?
A. I don't recall that.
Q. Do you know whether the Japanese employees of NEC shared anything they witnessed concerning the Back Seat Driver with third parties?
A. With third parties, I doubt it.
Q. You don't know that for a fact, though, do you?
A. Well, no. You know, they go drinking in bars just like everybody else, so it's not a policy to do that.
Q. Did you talk with anybody about the Back Seat Driver while you were drinking in a bar?
A. No.
MR. EDWARDS: I'm marking for the record RITT 22, which includes a nonconfidential copy of MIT 01284 through 01286.
Counsel, here is a copy for you.

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF PHILIP H. RITTMUELLER
November 21, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
2	8	Add "and the witness" after "Plaintiff"	Transcription error
21	3	Change "not to answer. To" to "not to answer, to"	Transcription error
84	19	Add the word "you" after "Does that satisfy"	Transcription error
101	22	Change "facts" to "fax"	Transcription error
137	19	Delete the words "like that"	Transcription error
153	21	Change "them" to "then"	Transcription error
207	8	Add "and the witness" after "Plaintiff"	Transcription error
210	1	Change "Front is Piece" to "Frontispiece"	Transcription error
226	11	Change "to" to "through"	Transcription error
227	17	Change "Widener" to "Weidemier"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Philip H. Rittmueller

Philip H. Rittmueller

Jan 8, 2007

EXHIBIT 10

Excerpts from the:

September 13, 2006
Deposition of
Lynn A. Streeter

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

Civil Action No. 05-10990 DPW

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiff,

COPY

vs.

HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED,

Defendant.

VIDEOTAPE DEPOSITION OF LYNN A. STREETER

SEPTEMBER 13, 2006

Pursuant to Notice taken on behalf of the Defendants at 2660 Canyon Boulevard, Boulder, Colorado, at 11:15 a.m., before Andrea Fine, Registered Professional Reporter and Notary Public within Colorado.

APPEARANCES:

STEVEN M. BAUER, ESQ.
PROSKAUER ROSE, LLP
One International Place
Fourteenth Floor
Boston, Massachusetts 02110-2600
Appearing on behalf of the Plaintiff.

JOANNA B. GUNDERSON, ESQ. and
MICHELLE A. H. FRANCIS, ESQ.
KIRKLAND & ELLIS, LLP
200 East Randolph Drive
Chicago, Illinois 60601
Appearing on behalf of the Defendant.

I N D E X

WHEREUPON, the following proceedings were taken pursuant to the Federal Rules of Civil Procedure:

LYNN A. STREETER

having been first duly sworn to state the whole truth, testified as follows:

EXAMINATION

BY MS. GUNDERSON:

Q. Good morning.

A. Good morning.

Q. You just heard me introduce myself, but my name is Joanna Gunderson. I represent Harman International Industries in this case.

Can you tell us your name for the record please.

A. Lynn A. Streeter.

Q. Where do you live?

A. I live at 625 Utica Avenue, Boulder, Colorado.

Q. Have you ever been deposed before?

A. No, I have not.

Q. I'm going to go over sort of a few rules of the road to start with. I'm going to be asking you a lot of questions today and it is very important that you hear each and every question that

A. Yes.
Q. Accurately?
A. Yes.
Q. Completely?
A. Yes.
Q. Is there any reason why you can't do all of these things today?
A. No.
Q. Are you feeling okay? Are you under any kind of medication or anything like that?
A. No.
Q. Are you prepared to give your best testimony today?
A. Yes.
Q. When did you meet Jim Davis?
A. I am not sure I have ever met him.
Q. When did you become -- are you aware of his work?
A. Yes. Oh, yes.
Q. When did you become aware of his work?
A. In the time that he was doing it, in the '80s, like 1988 time frame.
Q. Is there a particular time in 1988 that you remember?
A. Well, the person that I worked with,

Michael Leske at Bell Laboratories and Bellcore made frequent visits to MIT and was quite familiar with Jim's work and so would come back and tell us about it and also we got, you know, his thesis the day it was published basically.

Q. So before you received his thesis, did you only know of Mr. Davis' work through Mr. Leske?

A. And videotapes from MIT. You know, the media lab frequently would put out videotapes, so I believe the directory, the assistant for directions in Boston was on a videotape that they released.

Q. Did you see a videotape of the Back Seat Driver as well?

A. I don't recall seeing a Back Seat Driver videotape, just the Boston Museum.

Q. You said you received his thesis on the day it was published?

A. Maybe an exaggeration, but around the time that he was finished with it, yes.

Q. What time do you remember receiving it?

A. In 1989, some time during 1989.

Q. Do you remember whether it was summer, fall; was there an event that you remember?

A. I can't recall. I can't recall.

Q. It was a while ago.

make that recognition?
A. Well, when I looked at this thesis and what this guy had done, I mean, it was kind of incredible that somebody had managed to put it all together and make some system that was like a person sitting next to you giving you directions. I mean, it was so much different from anything anybody else had done and also the, sort of the technical machinations to make it all happen were pretty amazing.
Q. How did you get a copy of the thesis?
A. I think Jim Davis sent it to me.
Q. In the mail?
A. Yeah, uh-huh.
Q. You said earlier it was around the time that he had finished it?
A. I think so, yeah.
Q. In 1989?
A. Yeah.
Q. What makes you think it was 1989?
A. Because -- this is sort of reconstruction. Because I was still at Bellcore. The person next door, Mike Leske, I think might have actually gone up for the defense or something and I know I got the thesis just about the same time.

**CORRECTIONS TO DEPOSITION TRANSCRIPT
OF LYNN A. STREETER
September 13, 2006**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
Global	Global	Change "Leske" to "Lesk"	Transcription error
Global	Global	Change "media lab" to "Media Lab"	Transcription error
18	14	Change "directory assistance" to "Direction Assistance"	Clarification
56	17	Change "spacial" to "spatial"	Transcription error
64	3	Change "was" to "were"	Transcription error
84	14	Change "rogue" to "Rogue"	Transcription error
92	9	Change "Rom" to "ROM"	Transcription error
97	21	Change "compute" to "computationally"	Clarification
100	25	Change "directory" to "Direction"	Clarification
101	1	Change "assistance" to "Assistance"	Transcription error
102	13	Change "Sidener" to "Sidner"	Transcription error
103	21	Change "deck talk" to "DECtalk"	Transcription error
110	19	Change "compute" to "computationally"	Clarification
122	15	Change "Motley" to "Mottley"	Transcription error
128	12	Change "Dianne" to "Diane"	Transcription error
128	25	Change "Dianne's" to "Diane's"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Lynn A. Streeter
Lynn A. Streeter

Oct 19, 2006
Dated

EXHIBIT 11

Excerpts from the:

February 16, 2006
Deposition of
James R. Davis

VOLUME: I

PAGES: 1-248

EXHIBITS: 66-89

UNITED STATES DISTRICT COURT

DISTRICT OF MASSACHUSETTS

- - - - - - - - - - - - - - - - - - x

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiff,

v. Civil Action No. 05-10990-DPW

HARMAN INTERNATIONAL INDUSTRIES INCORPORATED,

Defendant.

- - - - - - - - - - - - - - - - - - x

CONFIDENTIAL

VIDEOTAPED DEPOSITION of JAMES R. DAVIS

February 16, 2006

9:17 a.m.

Proskauer Rose

One International Place

Boston, Massachusetts

Reporter: Michael D. O'Connor, RPR

APPEARANCES:

PROSKAUER ROSE LLP
By Steven M. Bauer, Esq.
One International Place
Boston, Massachusetts 02110
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For the Plaintiff.

KIRKLAND & ELLIS LLP
By Craig D. Leavell, Esq.
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Chicago, Illinois 60601
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For the Defendant.

Also Present: Richard Mendes, Videographer

INDEX

EXHIBITS

E X H I B I T S (Cont'd)

E X H I B I T S (Cont'd)

No.		Page
85	Document entitled, "Philips Technical Review"	181
86	Document entitled, "Abstract, Introduction"	210
87	Document entitled, "Abstract, Goals"	210
88	Document entitled "SAE Technical Paper Series"	243
89	Software document with Bates Nos. 04378 - 04850	246

(Mr. Leavell has retained the original exhibits)

P R O C E E D I N G S

VIDEOGRAPHER: Here begins videotape number one in the deposition of James R. Davis in the matter of Massachusetts Institute of Technology versus Harman International Industries, in U.S. District Court of Massachusetts, Case No. 05-1099-DPW.

Today's date is February 16, 2006. The time on the video monitor is 9:17 a.m. The video operator today is Richard Mendes, contracted by LegaLink, Boston, Massachusetts. This video deposition is taking place at Proskauer Rose, One International Place, Boston, Massachusetts.

Counsel, please voice identify yourselves and state whom you represent.

MR. BAUER: Steven Bauer from Proskauer Rose representing M.I.T. and the witness.

MR. LEAVELL: Craig Leavell from Kirkland & Ellis representing the Defendant Harman.

VIDEOGRAPHER: The court reporter today is Michael O'Connor of LegaLink Boston. Would the reporter please swear in the witness.

JAMES R. DAVIS

having been satisfactorily identified by the production of his driver's license, and duly sworn by the Notary Public, was examined and testified as follows:

VIDEOGRAPHER: Please begin.

DIRECT EXAMINATION

BY MR. LEAVELL:

Q. Good morning, sir.

A. Good morning.

Q. I'm going to hand you a copy of what's been previously marked as Defendant's Exhibit 32, a copy of U.S. Patent No. 5,177,685. If I refer to that as the '685 patent or your patent, will you understand that that's what I'm referring to today?

A. I will.

Q. You are the James R. Davis that's listed as an inventor on the face of the '685 patent?

A. I am.

Q. Mr. Davis, who do you currently work for?

A. The Ontario Principals Council of Toronto,

work, but before you signed your thesis on August 4th of 1989?

A. Sorry, would you please repeat that.

Q. Did you continue to use the working "Back Seat Driver" with other people around the Boston area between June of '89, which you say is when you knew it would work, and August of '89, when you signed your thesis paper?

A. First of all, I think what I testified is that by June of '89 I was confident that the system would work. The date that that confidence began to appear, I'm not sure what the earliest date of confidence was. Now I've forgotten the second part of your question, so I must ask you to repeat it.

Q. Did you continue to have people use "The Back Seat Driver" to navigate the Boston area after June of '89, but before you signed your thesis in August of '89, that two- or three-month period?

A. I do not recall the period when the experimentation began and the period when the experimentation ended. I do not recall what dates people drove in the car, so I cannot answer your question.

Q. Do you recall whether you personally were

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF JAMES R. DAVIS
February 16, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
Global	Global	Change all "media lab" to "Media Lab"	Transcription error
Global	Global	Change "Mr. Pasternak" to "Mr. Pasternack"	Transcription error
29	13-14	Change "general motors" to "General Motors"	Transcription error
38	17	Change "satisfies" to "says"	Transcription error
43	23	Change "a known" to "unknown"	Transcription error
58	18	Change "reasoned" to "recent"	Transcription error
92	3	Change "genius" to "genus"	Transcription error
95	11	Change "ability" to "a built"	Transcription error
102	16	Change "censored" to "censured"	Transcription error
108	14	Change "THE WITNESS" to "MR. LEAVELL"	Transcription error
115	10	Change "sites" to "cites"	Transcription error
115	24	Change "now" to "no"	Transcription error
117	19	Change "rephrase" to "rephrasing"	Transcription error
121	22	Change "band" to "banned"	Transcription error
122	6	Change "band" to "banned"	Transcription error
141	19	Change "never I am imagined" to "never imagined"	Transcription error
143	23	Change "undersatnd" to "understand"	Transcription error
147	8	Change "an affera" to "anaphora"	Transcription error
156	15	Change "no" to "so"	Transcription error
181	9	Change "Pierre Humbert" to "Pierrehumbert"	Transcription error
198	16	Change "limb" to "him"	Transcription error
209	3	Change "sent" to "spent"	Transcription error
245	1	Change "was in the" to "wasn't"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

James R. Davis

EXHIBIT 12

FAM 19.2

SYNTHETIC SPEECH FOR REAL TIME DIRECTION-GIVING

Christopher M. Schmandt and James Raymond Davis
The Media Laboratory
Massachusetts Institute of Technology

Abstract

The Back Seat Driver is a research prototype of a system to use speech synthesis as a navigational aid for an automobile equipped with localization equipment. We are evaluating the user interface by field trials. As this is work in progress, this paper will primarily give an overview of the system and describe its components. Included will be discussion of the map database, route finding algorithm, repair strategies, and the discourse generator.

Goals

The main goal of this project is to evaluate the utility of speech synthesis as the user interface to a real-time navigation system in an urban environment. Of particular concern is the discourse structure:

- how should driving acts be described?
- how can a description be generated from a route?
- how should timing considerations be applied?
- what kinds of feedback, both positive and negative, does the user require?
- what kinds of visual cues are most useful in describing an approaching location?

This information is gained from both laboratory simulations and field trials.

Our desire is to build the best possible real-time route describer. Although we believe a speech interface to the navigation unit is superior and safer than a visual interface, we do not plan to conduct direct comparison studies.

In the course of field trials to evaluate and improve our automatic direction giving, we hope to specify key components of the map database. We expect discourse behavior may need to vary with conditions (traffic, weather, day/night). It is likely that different visual cues may be useful in these situations. All must be represented in the database.

Geographic Database

Our database covers 41 square miles in the Boston area, including parts of Boston, Cambridge, Brookline, Somerville, and Watertown. It originated as a DIME (Dual Independent Map Encoding) file distributed by the United States Geological Survey[1]. A DIME file consists of a set of straight line segments, each with a name, a type, endpoints in longitude and latitude, and some additional information such as address numbers. Initially our database contained many errors. Correcting them required actually traveling most of the segments.

A DIME file alone is not sufficient for finding routes. The DIME files indicate physical connectivity, but route finding requires *legal* connectivity, i.e., one can legally drive from one segment to the next (one way streets are a simple example). We extended the data base format to explicitly represent legal connectivity. Since some streets are better than others, the database must include a measures of *quality*. We take this to be a largely subjective measure of the ease of locating and following a street. This allows the route finder to prefer to use streets of higher quality.

The generation of easy followed natural descriptions requires more extensions. We added a number of new segment types to distinguish bridges, underpasses, tunnels, rotaries, and access ramps. All these extensions were done for an earlier route finding project[2].

We are presently adding landmarks to the database. Drivers need landmarks to know how far to drive and when to turn. If the Back Seat Driver had eyes, it could simply choose landmarks as needed by looking for them in the landscape. Being blind, it must rely on landmarks coded into the map database. We have already added traffic lights to the landmark database. A main task now is to determine what else must be added.

System

Our vehicle is equipped with a localization unit built by NEC Home Electronics, Ltd., the project sponsor. It is a dead-reckoning position keeping system which uses speed and direction sensors. To compensate for error, it uses map matching on a map database stored on CD ROM. The system described more fully in [3].

As this is a research prototype, much of the computation is done in a base station computer laboratory (on a Symbolics Lisp Machine), rather than a computer on the vehicle. Two cellular

CH2724-3/89/0000-0288 $1.00

telephones link the computer to the car. The on board navigational hardware transmits position and velocity via modem and cellular phone to the base station. The base station computer does all route planning and discourse generation. Speech synthesis is performed in a commercial text-to-speech synthesizer (Dectalk) cabled to the Lisp Machine. Synthesized instructions to the driver are relayed via the second cellular link and a speaker phone in the car. The keypad of the second phone also serves as the driver's control unit for the Back Seat Driver. Through this keypad a driver selects a destination, requests repeats of spoken information, and accesses other services of the Back Seat Driver.

A block diagram of the system appears in Figure 2, below.

Discourse Strategies

The instructions are detailed and natural, and include a rich taxonomy of driving verbs. The dialog system uses cues such as vehicle speed and difficulty of driving actions to attempt to deliver instructions at the proper pace and in a timely manner. In addition, the system can anticipate some of the driver's possible mistakes and give warnings to avoid them.

If the driver does make a wrong turn, or misses a turn, the Back Seat Driver describes the error and then incrementally calculates a new route, rather than simply back-tracking to the point of the error. Route planning includes weighting for length of the trip, difficulty of driving maneuvers (such as left turns against traffic), street quality, and complexity of the spoken directions.

As opposed to much prior work in discourse generation, the Back Seat Driver is a real-time system which must factor in a number of temporal considerations. It needs to give each stage in the directions at just the right point, in terms of the time it takes to execute the driving maneuver as well as the speed of the vehicle approaching the intersection. For safety considerations, we would rather err on the side of giving the driver plenty of warning, but a cue given too far in advance may be miscued (e.g., a turn taken at an earlier intersection). Additionally, the software must consider the length of time it will take to recite an utterance. It is better to miss a turn and plan a new route than start describing the turn at a time when it may be unsafe to execute it (i.e., already well into an intersection).

Summary

The Back Seat Driver is already working in prototype form. Our present concerns are to determine what a spoken driving assistant should say, to understand how time and speed affect this decision, and to learn what features a map database must have to support generation of instructions.

Acknowledgments

The authors wish to gratefully acknowledge the support of NEC Home Electronics, Ltd.

References

[1] *Geographic Base File GBDF/DIME: 1980 Technical Documentation.* U.S. Department of Commerce, Data Users Services Division, 1980.

[2] James R. Davis and Thomas F. Trobaugh. *Direction Assistance.* Technical Report 1, MIT Media Laboratory Speech Group, Dec 1987.

[3] Osamu Ono, Hidemi Ooe, and Masahiro Sakamoto. CD-ROM Assisted Navigation System. In *Digest of Technical Papers,* pages 118–119, IEEE ICCE, 1988.

Figure 1: Map of Boston area

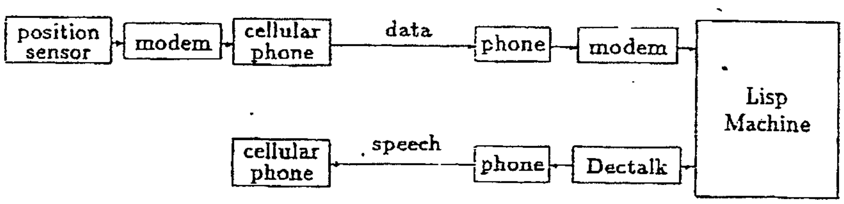

Figure 2: Block diagram of communications

EXHIBIT 13

SYNTHETIC SPEECH FOR REAL TIME DIRECTION-GIVING

Christopher M. Schmandt and James Raymond Davis
The Media Laboratory
Massachusetts Institute of Technology

Abstract

The **Back Seat Driver** is a research prototype of a system to use speech synthesis as a navigational aid for an automobile equipped with localization equipment. We are evaluating the user interface by field trials. As this is work in progress, this paper will primarily give an overview of the system and describe its components. Included will be discussion of the map database, route finding algorithm, repair strategies, and the discourse generator.

With advances in navigation technology and automotive electronics[3,8] has come increasing interest in cars that know where they are and can help you figure out how to reach your destination. Most prototype projects have used various forms of display to present this information, and not all of them have included route finding ability[2,5,7,10,12,13,14,15,18,20,21] For safety reasons, a display may not be particularly suited to this task, moreover there is some evidence that drivers do better following spoken directions than reading maps [19]. Our project, the Back Seat Driver, uses synthetic speech to give driving directions in real time. It plans a route, talks the driver through the route, and not only warns the driver when she has made an error, but also plans an alternate, corrective route.

This paper is an overview describing work in progress. We hope to publish more detailed explanations of the various portions at a later date. At the time of this writing (June, 1989) we have a working system on the road and are simultaneously conducting field trials and improving the direction giving ability and database. Although we do not aspire to prove that voice is better than graphics for direction giving, we do aim to build an optimal system. Early results are very encouraging, suggesting that speech may prove to be a powerful technology in automobiles of the future.

Talking about Directions

There are many factors which contribute to good route description by people, some of which our system only touches on. The problem is complex and simple solutions are not likely to produce comfortable interfaces.

A good route is not simply the shortest, but is more likely to be a combination of the fastest and the easiest to follow. "Easiest to follow" will, however, differ between directions given in advance and directions given in real time by a fellow passenger. Directions given in advance (as e.g. by [4], or the system at Hertz rental counters) must be simple, because the driver alone has the burden of interpreting and following the directions, and there is no help if the driver gets lost. When the direction giver is in the car it is practical to use minor streets or short cuts.

Good directions take into account conceptual *portions* of a route, which make it easier of the driver to keep track of her location on a more global basis. These may include named neighborhoods, types of neighborhoods (business, residential, parks) and types of roads (expressways, parkways, "main" roads, twisty or narrow streets).

By way of example, one of the authors was recently given directions at a car rental counter in a city new to him. The agent at the counter said *"As you leave the airport, keep bearing to the right. You'll go around the end of the runway and see signs for the Interstate north."* The "computerized driving directions" printed at the counter described the same route as 5 separate segments, with mileages and names for each. Especially as it was night, the latter were almost impossible to follow, while the former had succinctly captured the salient aspects of the route.

When the directions are being given by a passenger, the real-time aspect becomes more important. Directions will be given just in time, taking into account vehicle speed, difficulty of the expected maneuver, driving styles, and road, weather, and traffic conditions. During long highway stretches with little need for description, the direction giver must maintain the driver's confidence. The passenger will also be watching for errors and trying to warn against them, again based on fine observations of the vehicle's speed and

Manuscript received June 9, 1989

direction. When a mistake is made, the passenger will tell the driver about it and together they will take corrective action (which is unlikely to be simply a sudden stop!).

Project Goals

The main goal of this project is to evaluate the utility of speech synthesis as the user interface to a real-time navigation system in an urban environment. Of particular concern is the discourse structure:

- how should driving acts be described?
- how can a description be generated from a route?
- how should timing considerations be applied?
- what kinds of feedback, both positive and negative, does the user require?
- what kinds of visual cues are most useful in describing an approaching location?

This information is gained from both laboratory simulations and field trials.

Our desire is to build the best possible real-time route describer. Although we believe a speech interface to the navigation unit is superior and safer than a visual interface, we do not plan to conduct direct comparison studies.

In the course of field trials to evaluate and improve our automatic direction giving, we hope to specify key components of the map database. We expect discourse behavior may need to vary with conditions (traffic, weather, day/night). It is likely that different visual cues may be useful in these situations. All must be represented in the database.

Geographic Database

Our database covers 41 square miles in the Boston area, including parts of Boston, Cambridge, Brookline, Somerville, and Watertown. It originated as a DIME (Dual Independent Map Encoding) file distributed by the United States Geological Survey[1]. A DIME file consists of a set of straight line segments, each with a name, a type, endpoints in longitude and latitude, and some additional information such as address numbers. Initially our database contained many errors. Correcting them required actually traveling most of the segments.

A DIME file alone is not sufficient for finding routes. The DIME files indicate physical connectivity, but route finding requires *legal* connectivity, i.e., one can legally drive from one segment to the next (one way streets are a simple example). We extended the data base format to explicitly represent legal connectivity. Since some streets are better than others, the database must include a measures of *quality*. We take this to be a largely subjective measure of the ease of locating and following a street. This allows the route finder to prefer to use streets of higher quality.

The generation of easily followed natural descriptions requires more extensions. We added a number of new segment types to distinguish bridges, underpasses, tunnels, rotaries, and access ramps. All these extensions were done for an earlier route finding project[4].

We are presently adding landmarks to the database. Drivers need landmarks to know how far to drive and when to turn. If the Back Seat Driver had eyes, it could simply choose landmarks as needed by looking for them in the landscape. Being blind, it must rely on landmarks coded into the map database. We have added traffic lights, stop signs, and some buildings to the portions of the landmark database. A main task now is to determine what else must be added.

In addition to landmarks, other information is useful for providing assistance following a route. We found it very useful to add lane information, both number of lanes as well as any turn restrictions on lanes (e.g. left turn only). On short street segments, it is important to give lane advice (*"After the turn you'll want to get into the left hand lane."*) or else the driver may be unable to make the following turn. Lane warnings (*"Stay out of the left turn lane."*) are also important driving cues.

An interesting problem arises at complex intersections, typically a maze of ramps between major arteries, possibly at different elevations (see figure 1). Such intersections are typically not accurately recorded in the map. Furthermore, limitations in the resolution of the position tracking equipment make it difficult to distinguish one segment from another, especially as they are likely to diverge at narrow angles. The combination of uncertainties in the map and uncertainties in position make it difficult to give a clear spoken directions. Fortunately these intersections are usually well signed, so the Back Seat Driver can give directions by referring to the signs, e.g. *"Follow the signs to the expressways and airport"*. The wording of these signs needs to be in the database. It is important that Back Seat Driver's understand what the sign says, not simply utter the words. There are two reasons for this. First, our internal representation for text is based on syntactic structure, not text strings. Second, the objects mentioned in the signs (cities and roads) should be entered into the discourse model. They should become salient for future reference. This means that the text of a sign must be parsed, so that e.g. the sign text "Cambridge, Somerville, and Storrow Drive" should become a conjunction of the two cities "Cambridge" and "Somerville" and the street named "Storrow Drive".

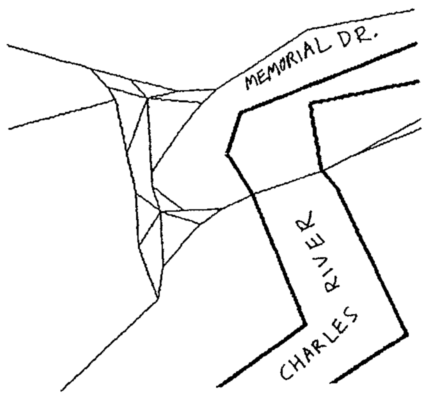

Figure 1: Access ramps at an interchange

System

Our vehicle is equipped with a localization unit built by NEC Home Electronics, Ltd., the project sponsor. It is a dead-reckoning position keeping system which uses speed and direction sensors. To compensate for error, it uses map matching on a map database stored on CD ROM. The system described more fully in [16,17]

As this is a research prototype, much of the computation is done in a base station computer laboratory (on a Symbolics Lisp Machine), rather than a computer on the vehicle. Two cellular telephones link the computer to the car. The on board navigational hardware transmits position and velocity via modem and cellular phone to the base station. The base station computer does all route planning and discourse generation. Speech synthesis is performed in a commercial text-to-speech synthesizer (Dectalk) cabled to the Lisp Machine. Synthesized instructions to the driver are relayed via the second cellular link and a speaker phone in the car. The keypad of the second phone also serves as the driver's control unit for the Back Seat Driver. Through this keypad a driver selects a destination, requests repeats of spoken information, and accesses other services of the Back Seat Driver.

A block diagram of the system appears in figure 2.

Routes

The Back Seat Driver can find the shortest, fastest, or most easily followed route. Route finding uses an A* search algorithm[11]. Depending on the driver's preference, one of three cost metrics is used, The *distance* metric is simply the sum of the lengths of the segments which compose a route. The *speed* metric scales each distance by a factor dependent on street quality. In addition, penalties are incurred for turns (more for left turns than right), stop signs, and traffic lights (which may be red). The *simplicity* metric, following [6], seeks to minimize the number of turns by imposing a distance penalty for each turn.

Discourse Strategies

The instructions are detailed and natural, and include a rich taxonomy of driving verbs. The dialog system uses cues such as vehicle speed and difficulty of driving actions to attempt to deliver instructions at the proper pace and in a timely manner. In addition, the system can anticipate some of the driver's possible mistakes and give warnings to avoid them.

Describing a route requires going from a series of segments (typically city blocks) in the database to a series of travel segments which will be separated by decision points. For example, going straight down a main street for five blocks will not be thought of by the driver as five separate acts, but rather one street traversal. A key piece of this analysis is that the need to make a decision is based on knowledge of what is *obvious*. Drivers do not want to be nagged at each corner to continue straight, but when they come to a questionable fork in the road they do want to be told which way to proceed.

If the driver does make a wrong turn, or misses a turn, the Back Seat Driver describes the error and then incrementally calculates a new route, rather than simply backtracking to the point of the error. Route planning includes weighting for length of the trip, difficulty of driving maneuvers (such as left turns against traffic), street quality, and complexity of the spoken directions.

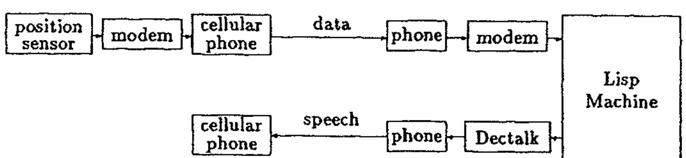

Figure 2: Communications block diagram

As opposed to much prior work in discourse generation, the Back Seat Driver is a real-time system which must factor in a number of temporal considerations. It needs to give each stage in the directions at just the right point, in terms of the time it takes to execute the driving maneuver as well as the speed of the vehicle approaching the intersection. For safety considerations, we would rather err on the side of giving the driver plenty of warning, but a cue given too far in advance may be miscued (e.g., a turn taken at an earlier intersection). Additionally, the software must consider the length of time it will take to recite an utterance. It is better to miss a turn and plan a new route than start describing the turn at a time when it may be unsafe to execute it (i.e., already well into an intersection).

There are several reasons to give instructions before the act, if time permits. One is to allow the driver to hear the instructions several times, and the other is to allow time to prepare for some acts, e.g., turns from a multi-lane street. These advance notices are lower priority than the description of the act itself, according to an internal set of system goals. Thus, they can be presented if there is adequate time, but will be ignored if the vehicle is approaching the next decision point too quickly.

Reassuring

While the driver is following a route, the system adopts a persistent goal of keeping the user reassured about her progress and the system's reliability. If Back Seat Driver were a human, this might be unnecessary, since the driver could see for herself whether the navigator was awake and attending to the road and driver. But the driver can not see the system, and so needs some periodic evidence that the system is still there.

One piece of evidence is the safety warnings the system gives (e.g. *"slow down"* before a turn), but if all is going well, there will not be any. The system gives two other kinds of evidence that things are going well. First, when the user completes an action, the system acknowledges the driver's correct action, saying something like *"nice work"* or *"good"*. This feature is very popular with most test drivers.

The second form of evidence is to make insignificant remarks about the roads nearby, the weather, and so on. If the driver assumes that the navigator is being cooperative, as set out in Grice's maxims of cooperative conversation [9], then the driver can infer that everything is going well, for otherwise the navigator would not speak of trivial matters. It isn't clear, however, that one really wants a chatty speech synthesizer. Certainly this feature could be useful in a rented car in a new city, where it might actually have some interesting things to say.

Summary

The following is one of the more complex utterances of the Back Seat Driver to date. It summarizes many key points mentioned in this paper, and indicates the current state of operability of the discourse generator:

> Get in the left lane because you're going to take a left at the next set of lights. It's a complicated intersection because there are two streets on the left. You want the sharper of the two. It's also the better of them. After the turn, get into the right lane.

The Back Seat Driver is already working in prototype form. Our present concerns are to determine what a spoken driving assistant should say, to understand how time and speed affect this decision, and to learn what features a map database must have to support generation of instructions.

Acknowledgments

The authors wish to gratefully acknowledge the support of NEC Home Electronics, Ltd.

References

[1] *Geographic Base File GBDF/DIME: 1980 Technical Documentation.* U.S. Department of Commerce, Data Users Services Division, 1980.

[2] Peter Braegas. Function, Equipment, and Field Testing of a Route Guidance and Information System for Drivers (ALI). *IEEE Transactions on Vehicular Technology*, VT-29(2):216–225, May 1980.

[3] Donald F. Cooke. Vehicle Navigation Appliances. In *AUTO CARTO 7 International Symposium on Automation in Cartography*, pages 108–115, March 1985.

[4] James R. Davis and Thomas F. Trobaugh. *Direction Assistance.* Technical Report 1, MIT Media Laboratory Speech Group, Dec 1987.

[5] Ronald A. Dork. Satellite Navigation Systems for Land Vehicles. In *IEEE Position and Location Symposium*, pages 414–418, 1986. IEEE 86CH2365-5.

[6] R. J. Elliot and M. E. Lesk. Route finding in street maps by computers and people. In *Proceedings of the National Conference on Artificial Intelligence*, pages 258–261, 1982.

[7] Edward J. Krakiwsky et al. Research into electronic maps and automatic vehicle location. In *AUTO CARTO 8 International Symposium on Automation in Cartography*, 1987.

[8] Robert L. French. Automobile Navigation: Where is it going? In *IEEE Position and Location Symposium*, pages 406–413, 1986. IEEE 86CH2365-5.

[9] H. P. Grice. Logic and conversation. In Cole and Morgan, editors, *Syntax and Semantics: Speech Acts*, pages 41–58, Academic Press, 1975.

[10] Peter Haeussermann. *On Board Computer System for Navigation, Orientation, and Route Optimization.* Technical Paper Series 840483, Society of Automotive Engineers, 1984.

[11] P. E. Hart, N. J. Nilsson, and B. Raphael. A formal basis for the heuristic determination of minimum cost paths. *IEEE Transactions on SSC*, 4:100–107, 1968.

[12] Stanley K. Honey, Marvin S. White Jr., and Walter B. Zavoli. Extending Low Cost Land Navigation Into Systems Information Distribution and Control. In *IEEE Position and Location Symposium*, pages 439–444, 1986. IEEE 86CH2365-5.

[13] Toshiyuki Itoh, Yasuhiko Okada, Akira Endoh, and Kenji Suzuki. *Navigation Systems Using GPS for Vehicles.* Technical Paper Series 861360, Society of Automotive Engineers, 1986.

[14] M. D. Kotzin and A. P. van den Heuvel. Dead Reckoning Vehicle Location using a solid state rate gyro. In *Proceedings of the 31rst IEEE Vehicular Technology Conference*, pages 169–172, April 1981. IEEE publication 81CH1638-6.

[15] Ernst Peter Neukirchner and Wolf Zechnall. Digital Map Data Bases for Autonomous Vehicle Navigation Systems. In *IEEE Position and Location Symposium*, pages 320–324, 1986. IEEE 86CH2365-5.

[16] Osamu Ono, Hidemi Ooe, and Masahiro Sakamoto. CD-ROM Assisted Navigation System. In *Digest of Technical Papers*, pages 118–119, IEEE ICCE, 1988.

[17] Osamu Ono, Hidemi Ooe, and Masahiro Sakamoto. Navigation and communication system. In *Digest of Technical Papers*, IEEE ICCE, 1989.

[18] Otmar Pilsak. *EVA: An electronic Traffic Pilot for Motorists.* Technical Paper Series 860346, Society of Automotive Engineers, 1986.

[19] Lynn A. Streeter, Diane Vitello, and Susan A. Wonsiewicz. How to tell people where to go: comparing navigational aids. *International Journal of Man/Machine Systems*, 22(5):549–562, May 1985.

[20] Katsutoshi Tagami et al. *Electro Gyro-Cator: New Intertial Navigation System for Use in Automobiles.* Technical Paper Series 830659, Society of Automotive Engineers, 1983.

[21] Walter B. Zavoli and Stanley K. Honey. Map Matching Augmented Dead Reckoning. In *Proceedings of the 35th IEEE Vehicular Technology Conference*, pages 359–362, 1986. IEEE CH2308-5.

MR. SCHMANDT received his B.S. in Computer Science from MIT and an M.S. in computer graphics from MIT's Architecture Machine Group. He is currently a Principal Research Scientist and director of the Speech Research Group of the Media Laboratory at M.I.T.

His research interests are focused on interactive computer systems and human-interface issues of synchronous and asynchronous communication. His work emphasizes voice interaction for telecommunication based applications, with a goal of describing and then emulating human conversational behavior.

EXHIBIT 14

Back Seat Driver: voice assisted automobile navigation

by

James Raymond Davis

B.S.A.D., Massachusetts Institute of Technology (1977)

Submitted to the Media Arts and Sciences Section
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 1989

Signature of Author ....
Media Arts and Sciences Section
August 4, 1989

Certified by ....
Nicholas P. Negroponte
Professor of Media Technology
Thesis Supervisor

Accepted by ....
Stephen A. Benton
Chairman, Departmental Committee on Graduate Students

Back Seat Driver: voice assisted automobile navigation

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James Raymond Davis

Submitted to the Media Arts and Sciences Section
on August 4, 1989, in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Abstract

The Back Seat Driver is a computer navigation assistant for drivers in a city. It differs from earlier navigation programs by using speech, rather than graphics, to give instructions. The advantages of speech are that the driver's eyes are left free for driving and that the spoken directions contain information not easily portrayed in pictures. The program talks about the features of the road in the same way the driver sees them, giving the impression that the program is actually is in the car.

Driving instructions are modeled after those given by people. The two issues for spoken directions are *what to say* (content) and *when to say it* (timing). The content of the instructions tells the driver what to do and where to do it. The program has a large taxonomy of intersection types, and chooses verbs to indicate the kind of intersection and the way of moving through it. The instructions refer to landmarks and timing to tell the driver when to act.

Timing is critical because speech is transient. Drivers hear instructions just in time to take the required action, and thus need not remember the instruction or exert effort looking for the place to act. The program also gives instructions in advance, if time allows, and the driver may request additional instructions at any time. If the driver makes a mistake the program describes the mistake, without casting blame, then finds a new route from the current location.

Street map data bases for navigation programs must distinguish between *physical* connectivity (how pieces of pavement connect) and *legal* connectivity (whether one can legally drive onto a physically connected piece of pavement). Legal connectivity is essential for route finding, and physical connectivity for describing the route. The database must also contain all landmark information, since the program has no "eyes".

The Back Seat Driver is an actual working prototype. It has successfully guided drivers unfamiliar with Cambridge to their destinations. Although much work remains, it is easy to foresee a practical implementation in the future.

Thesis Supervisor: Nicholas P. Negroponte
Title: Professor of Media Technology

EXHIBIT 15

The Back Seat Driver: Real Time Spoken Driving Instructions

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Abstract

The Back Seat Driver is an automobile navigation aid which uses synthetic speech to give driving instructions in real time to the driver of a car. The advantage of speech over visual aids is that it leaves the driver's eyes free for driving, however it also poses special problems. This paper describes the strategies employed by the Back Seat Driver to successfully use speech. We hope this paper will persuade you of the value of speech in driving directions.

Introduction

The Back Seat Driver uses synthetic speech to give driving instructions in real time to the driver of a car. Speech is the only output channel it uses. There are no graphics. This paper discusses the advantages and problems arising from our exclusive use of speech to provide directions. The first section presents a brief overview of the Back Seat Driver. The second section describes the linguistic abilities of the Back Seat Driver. The final section describes the problems we have encountered because of our exclusive use of speech, and how we have overcome them.

System Overview

The architecture of the Back Seat Driver is shown in figure 1. At the center of the Back Seat Driver is the map database. The street map represents two ways in which streets can be connected: *physical* connectivity means it is physically possible to drive from one segment to another, and *legal* connectivity means it is lawful to do so. Legal connectivity is obviously needed to find legal routes, and physical connectivity for correctly describing intersections. The street map also includes traffic lights, stop signs, the number of lanes, and the location of all gas stations. These features are useful for both route finding (since, e.g. fast routes should avoid traffic lights) and for descriptions. The location system (supplied by the project sponsor, NEC) determines the current position of the vehicle by dead reckoning and map matching. It is further described in [3]. The driver gives the Back Seat Driver a destination by entering an address on a keyboard.

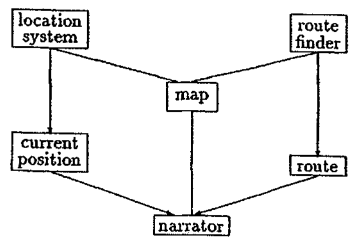

Figure 1: Back Seat Driver components

Using this map, the route finder can find the shortest route, the simplest one, or the one most easily followed, depending on the driver's preference.

The *narrator* is the subject of this paper. It generates instructions spoken by a speech synthesizer (a Dectalk). The narrator follows the driver's progress along the route. It decides what to say by comparing the current position against the map. The system follows the driver's progress, giving each instruction just when needed. If the time between instructions is long, the program gives the instruction twice, first in a detail, and later in a brief form. When not otherwise occupied, the system may deliver voice mail messages, weather reports, or commentary about the route. If the driver makes a mistake the system automatically finds an alternate route and continues.

The system has been running in prototype form since April 1989. It has been successfully used by drivers who have never driven in Boston. A somewhat longer description of the system appears in [4]. A complete description of the system appears in [1].

Linguistic Abilities

In designing the Back Seat Driver we chose to use speech as the sole means of providing driving instructions for two reasons. First, we believe that the driver's eyes are already employed watching traffic, and best left undisturbed. Second, we know that the alternative (map displays) will not work for those people who have difficulty reading maps[5]. We were also influenced by an experiment on route following which compared spoken instructions with paper maps[6]. Subjects who heard spoken directions did better than those with maps, and also better than those with *both* sources of guidance. Although this experiment does not compare real time speech to real time maps, it does suggest that spoken directions might be easier to follow than visual directions.

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Classifying Actions

Based on a study of how people naturally give spoken driving instructions, we developed a taxonomy of intersection types (Figure 2). This taxonomy is necessary in order to describe an intersection in the same way that a person would. For example, people talk about a "T" turn differently than a "fork" (or "Y") in the road. It is important that instructions match people's perceptions of the the world they see.

The proper classification of an intersection depends upon the topology (how many streets are at an intersection), the geometry (the angles among them), and the types of roads involved. For instance, the difference between the "T" and "fork" mentioned above is one of geometry, not topology (figure 3), and the difference between a "fork" and an exit from a highway is that one of the two roads in the "Y" of the exit is much larger than the other.

In our system, a route is a sequence of street segments leading from the origin to the destination. We consider every connection from one segment to another as an "intersection", even if there is only one next segment at the intersection. At any moment, the car will be on one of the segments of the route, approaching an intersection (unless an error occurs, which is handled as discussed below). The task of the Back Seat Driver is to say whatever is necessary to get the driver to go from the current segment, across the intersection, to the next segment of the route.

The items in the taxonomy of intersection types are called **acts**. We use an object oriented programming methodology, so for each act there is a corresponding "expert". The Back Seat Driver generates speech by consulting these experts. At any moment, there will be exactly one expert in charge of telling the driver what to do. To select this expert, the Back Seat Driver asks each expert in turn to decide whether it applies to the intersection. The experts are consulted in a fixed order, the most specific ones first. The first expert to claim responsibility is selected. This expert then has the responsibility of deciding what (if anything) to say.

- CONTINUE
- FORCED-TURN
- TURN-AROUND
- TURN
- FORK
- ENTER
- EXIT
- ONTO-ROTARY
- EXIT-ROTARY
- STOP

Figure 2: Act taxonomy

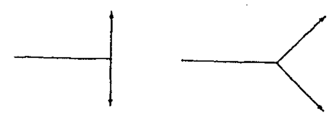

Figure 3: A "T" and a "Y" have the same topology

Describing actions

Each expert is able to generate text which describes the intersection. A description for an act must tell the driver two things: what to do and when (or where) to do it. "What to do" is expressed by a more or less constant verb phrase which depends upon the taxonomic classification, but may also depend upon specifics of the intersection. Thus a slight turn might be described by the verb "bear" where a sharper turn would be a "turn". The descriptions can be verbose or brief, and they can be expressed in past, present, or future tense. (We'll say why this flexibility is needed below.)

Saying "when"

Our study of natural instructions showed us that people almost never use distance as a cue for when to act. This is in sharp contrast to the textual directions provided by systems such as that of the Hertz rental company. Instead, people use two strategies. They wait until the driver is close to the intersection before saying anything, and/or they use a great variety of landmarks – including traffic lights, stop signs, other signs, buildings, road features, and the positions of other moving objects (e.g. "Follow that car."). The Back Seat Driver adopts both of these strategies.

Speech is especially useful as a cue for timing because speech is a temporal event, with a clear beginning and ending time. You know when someone begins to speak and when they finish. Someone peering at a map displayed on a CRT may have trouble distinguishing two adjacent streets, but there is no mistaking the word "now". Using time as a cue minimizes the workload on the driver, because the navigator absorbs the burden of remembering when to act. It also demands that the navigator have an accurate idea of where the car is. Our system demands positional accuracy of no greater than 10 meters for successful operation.

The Back Seat Driver's use of landmarks is unique in vehicle navigation systems. Our database began as a DIME file, but we extended it to include traffic lights, stop signs, road features (such as overpasses, bridges, and tunnels), distinctive signs, and the location of gas stations. Most of these are represented as attributes of the segments in the map database. To select a landmark for an intersection, the Back Seat Driver looks backwards from the intersection for the closest landmark which is also unique – that is, it prefers to say "take the first right after the underpass" rather than "take a right at the second set of lights". We think this makes the landmark easier to remember.

The Back Seat Driver does not speak at every single intersection. In the great majority of cases, it is perfectly obvious to the driver what to do (namely, to continue on forward). The action experts are also capable of deciding when the action at the intersection should be obvious to the driver. At present, the only action that is *ever* treated as obvious is CONTINUE. It is usually obvious to continue across an intersection, but we have found that what is obvious to one driver may not be so to another. Some people, for instance, are not comfortable driving across a major intersection unless they are instructed to do so. The expert can be somewhat customized so that its judgment of "obviousness" will correspond to that of the driver. If the action at the next intersection is obvious, the Back Seat Driver says nothing about it, and looks ahead for action at the next intersection, until it finds one that is *not* obvious.

The Back Seat Driver gives instructions just prior to the action. It also gives instructions further in advance, if time permits. This is especially useful when the instructions are complicated, as they are at some intersections. It is also able to give instructions "on demand". We call this the "what now" button. Drivers use this button for two reasons. Sometimes they are unsure whether they have come to the place where they are supposed to act, so they press the button to find out. At other times, they reach an intersection where the Back Seat Driver says nothing, because it believes the action is obvious, but it is not obvious to the driver. When the driver hits the "what now" button, the expert for the upcoming intersection describes it, even if it is considered to be obvious.

Talking about past and future

An advantage of language over pictures or gestures is that it can express events in the past or future. This advantage is well appreciated by readers of fiction, but may not yet be appreciated by designers of navigation systems. A navigation system should be able to talk about the past and future of the route, not just the present.

Drivers often need advance notice to prepare for an action. An example is what we call **lane advice**, which tells the driver to get into, or stay out of, a given lane. Lane advice is common in natural directions, and is one of the most appreciated features of the Back Seat Driver.

One reason for talking about the past is to describe mistakes. Drivers do not always follow the route the Back Seat Driver intends, either because of a mistake by the driver, the program, or external circumstances. When a mistake occurs, the Back Seat Driver finds a new route from the current location to the destination, while the driver is still moving. It also describes the mistake, saying something like "Oops, I meant for you to go straight." We think it is important that the system tell the user that there has been a mistake (without casting any blame on the user!) so that the user will come to better understand the system's style of instruction giving, and so that the user will remain confident in the system's understanding of the route. Talking about past and future actions is important in navigation. Speech seems to be the easiest way of doing this.

Example

As an example, here's a sample of the description of the left turn from Fulkerson Street to Main Street in Kendall Square, Cambridge.

> Get in the left lane because you're going to take a left at the next set of lights. It's a complicated intersection because there are two streets on the left. You want the sharper of the two. It's also the better of them. After the turn, get into the right lane.

This description was generated by the TURN expert in verbose form. It begins with some lane advice, then specifies the next action and provides a landmark for the place. The turn is described, and the proper street is described by two independent cues, one geometric, and one qualitative. Finally, the text provides a second piece of advice for after the turn.

Summary

The speech interface of the Back Seat Driver provides instructions without requiring the driver to look away from the road. Using speech permits us to talk about the past and the future as well as the present, and to give more detailed descriptions of the act than are possible with maps. Furthermore, it allows us to specify timing with great precision. But speech is not without its problems. The next section will discuss them, and the steps we have made to overcome them.

Liabilities of Speech

The advantages of a spoken language interface, as described above, do not come without cost. First, there are problems common to any natural language interface: while it is not terribly difficult to make a rudimentary interface, language generation requires substantial programming effort to be fluent and natural. Language is complicated, and people have literally a lifetime of experience with it, and are sensitive to fine nuances. On the other hand, having made this effort, we can exploit these nuances to to convey extra information.

A second problem is that a natural language interface is only useful to those who speak the language. In our experience, only a few non-native speakers have been able to understand the directions. Map displays have conventions of their own, but are more universal than natural language. We have also noticed that some driving terms used in the Boston area (e.g. "rotary") are not in the dialect of other English speakers. In our view, universality is not a prime concern. We believe that systems should be custom fit to the idiosyncrasies of their owners. The Back Seat Driver in your car should speak to you in the language and terms that are best for you as an individual, not you as a generic human.

The remainder of this section discusses problems specific to *spoken* natural language generation.

Speech takes time

As we said above, speech is inherently temporal. We take advantage of this when we use speech as a timing cue, but it also can be a difficulty. A real time spoken navigation system must plan its speech to ensure that it has enough time to say what it needs to say. If little time remains, it must say less (or speak more quickly), or ask the driver to slow down. We handle this problem by tracking the vehicle's position and velocity, and by modeling the time required to speak. The Back Seat Driver begins its speech at a time chosen to be early enough to allow the driver to hear the entire message, understand it, and react to it, before the point where action must be taken. The model of reaction time includes a constant for the driver's comprehension and a variable time which depends on the speed of the car, according to the maximum comfortable braking deceleration.

The temporal nature of speech also requires that the Back Seat Driver sometime combine instructions into a single utterance. When uttering an instruction, the Back Seat Driver looks ahead for the next instruction. If it determines that the time between the end of the execution of the current instruction and the beginning of the next is too short to allow it to speak the next instruction, it combines that text into the current one.

The Back Seat Driver does more than just give directions. Among other things, it also reads electronic mail messages from our office, gives weather reports, and makes comments about the route and road. Because speech takes time, and because a spoken utterance is only useful if completely spoken, the Back Seat Driver must carefully allocate the right to speak among potential tasks. It is undesirable for one task's speech to interrupt another's.

Speech can be misunderstood

A liability of speech, and synthetic speech in particular, is that speech can be misunderstood. This is particularly a problem with street names, because there are constraints that can help a driver correct a partially misunderstood name. A driver hearing an utterance that sounds like "Tarn reft" can guess that it is a corrupt form of "Turn left", but nothing can help the driver know what was intended by "Tarn Street". Directions should not use street names, because street name signs may be hard to see, misaligned, or simply missing. The importance of this first became apparent when we observed one driver who consistently misunderstood names, but also did not realize that he had misunderstood. Furthermore, the strength of his faith in the name was so strong that he drove straight through intersections, despite being told to "take the next left". This is probably the right thing to do with human instructions, where names are usually correctly understood, but street counts (e.g. "the third right") are imprecise or simply wrong. Our directions are phrased to minimize the use of street names in instructions. A typical text is: "Take the second left. It's Franklin Street."

Speech is transient

Information presented by speech does not persist, except in short term memory. We have already mentioned this as a reason why instructions should be given as late as possible. Another consequence of the transience of speech is that the system must be able to repeat itself at anytime, since the driver may not always be able to hear the speech. Repetition in turn poses a challenge.

since, unlike a program which reads the newspaper aloud, a literal repetition may not be appropriate, since the situation changes over time. For instance, if asked to repeat "Take the third left", the system may instead say "Take the second left" if the car has crossed an intersection. The consequence for the implementation is that the system retains not its previous words, but rather the previous reason for speaking. When asked to repeat, it invokes the same function that produced the last utterance.

A second problem with the ephemeral quality of speech is that the driver has no evidence of the program's existence except when it is speaking. We consider it very important that the driver have continued confidence that the program is running correctly, is aware of the driver's position and progress, and is "seeing" the world in the same way the driver does. We have devoted substantial effort to maintaining the illusion of **co-presence**.

In the introduction to this section, we said that the nuances of language could be used to convey much information. Co-presence is an idea communicated more by nuance than by explicit statement. (People would laugh if the system said "I'm right here with you." It sounds like something a therapist would say.) One way we indicate co-presence through nuance is by using **deictic** pronouns. Deictics are words that "point" at something. In English, we have four deictic pronouns: "this", "that", "these", and "those". The first two are singular, the second plural. The difference between "this" and "that" (and "these" and "those") is that "this" refers to something close. We use this in referring to landmarks. When the landmark is close, we use the proximal form (e.g. "these lights") ; when distant, we use a brief noun phrase (e.g. "the next set of lights"). This is important. When a driver is stopped 30 meters back from a stop light, it may be literally true to say "turn left at the next set of lights", but it will confuse the driver.

A second means of conveying co-presence is to acknowledge the driver's actions. After the driver carries out an instruction the system briefly acknowledges the act if there is time, and if the act was not so simple (e.g. continuing straight) as to need no acknowledgment. This acknowledgment is a short phrase like "Okay". Some drivers dislike acknowledgments, so they can be disabled, but most find the confirmation comforting. The timing of the acknowledgment does much to confirm the driver's sense that the program really knows where the car is. Another source of acknowledgment is the use of **cue words** in the instructions. It will often by the case that the route calls for the driver to do the same thing twice (e.g. make two left turns). The speech synthesizer we use has very consistent pronunciation, and drivers sometimes get the impression that the system is

repeating itself because it is in error (like a record skipping). The acknowledgments help to dispel this, but we also cause the text to include cue words such as "another". These indicate that the system is aware of its earlier speech and the driver's previous actions.

Yet another means of conveying co-presence is to make occasional remarks about the road and the route. These remarks indicate that the program is correctly oriented. As an example, when the road makes a sweeping bend to one side, the program speaks of this as if it were an instruction ("Follow the road as it bends to the right.") even though the driver has no choice in what to do. The program also warns the driver about potentially hazardous situations, such the road changing from one-way to two-way, or a decrease in the number of lanes. As with acknowledgments, these warnings can be disabled if the driver dislikes them. Other remarks have less to do with the route. We justify these by the maxims of cooperative conversations formulated by philosopher H. P. Grice[2]. His maxim of QUANTITY (part 1) says: "Make your contribution as informative as is required." Grice explains that one can convey information by appearing to flout the maxim. In this case, a driver can reason as follow: "The program, like all cooperative agencies, obeys the maxim of quantity. Therefore, it is had something important to say, it would say it. The program said nothing of great significance, therefore there is nothing urgently requiring my attention. So everything is well." At present, our "Gricean" utterances are trivial observations about the weather, but we are re-designing them to convey useful information about the city.

Summary

A speech interface for giving driving instructions has several advantages over a graphics interface. There are problems with natural language interfaces in general, and speech in particular, but they can all be overcome. The result is an excellent aid for navigation.

Acknowledgments

The authors wish to gratefully acknowledge the support of NEC Home Electronics, Ltd.

References

[1] James Raymond Davis. *Back Seat Driver: voice assisted automobile navigation.* PhD thesis, Massachusetts Institute of Technology, September 1989.

[2] H. P. Grice. Logic and conversation. In Cole and Morgan, editors, *Syntax and Semantics: Speech Acts*, volume 3, pages 41–58. Academic Press, 1975.

[3] Osamu Ono, Hidemi Ooe, and Masahiro Sakamoto. CD-ROM Assisted Navigation System. In *Digest of Technical Papers*, pages 118–119. IEEE ICCE, 1988.

[4] Christopher M. Schmandt and James R. Davis. Synthetic speech for real time direction giving. *IEEE Transaactions on Consumer Electronics*, page (to appear), 1989.

[5] Lynn A. Streeter and Diane Vitello. A profile of drivers' map reading abilities. *Human Factors*, 28:223–239, 1986.

[6] Lynn A. Streeter, Diane Vitello, and Susan A. Wonsiewicz. How to tell people where to go: comparing navigational aids. *International Journal of Man/Machine Systems*, 22(5):549–562, May 1985.

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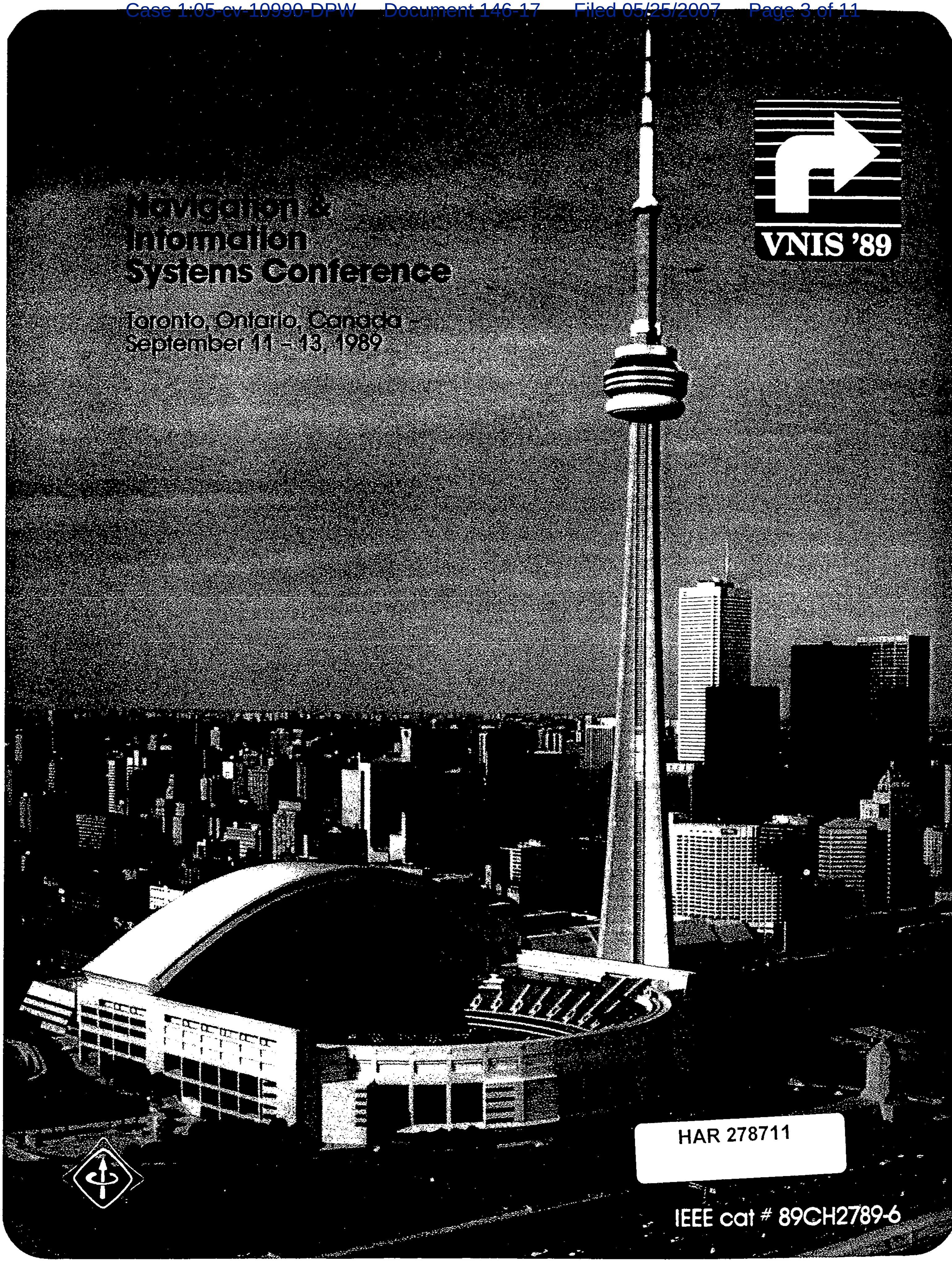
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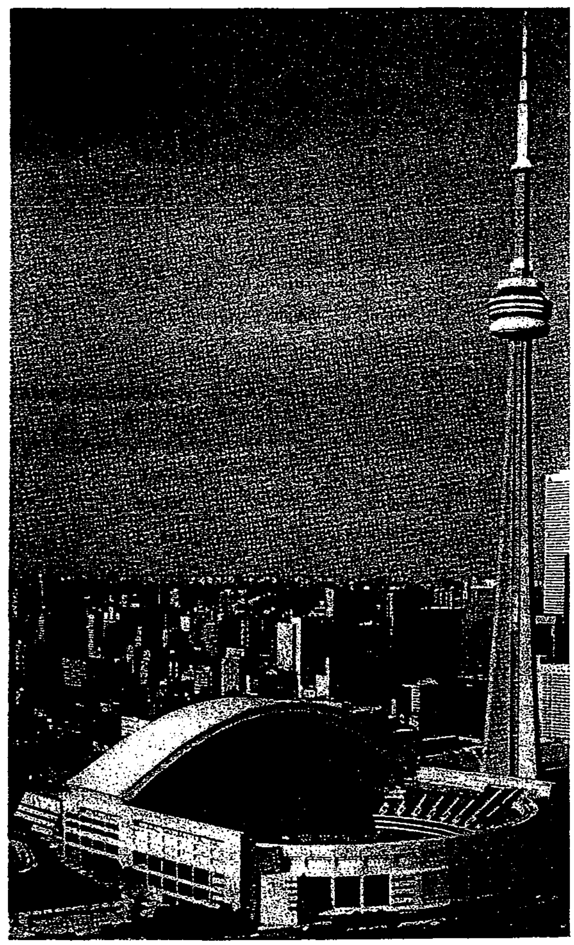

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IEEE Vehicle Navigation and Information Systems Conference (VNIS '89) (1st : 1989 : Toronto)

Conference record of papers presented at the IEEE Vehicle Navigation and Information Systems Conference (VNIS '89) / compiled and edited by D.H.M. Reekie, E.R. Case and J. Tsai

564p. includes appendix 28 cm

ISSN 0843-932X
ISBN 0-9692316-2-8

1. Navigation-Automation-Congresses. 2. Navigation-Communication systems-Congresses. 3. Mobile communication systems-Congresses I. IEEE Vehicular Technology Society. II. Reekie, D.H.M. III. Case, E.R. IV. Tsai, J. V. Title

V399 359.002854

IEEE cat No 89CH2789-6

Library of Congress No 89-85550

Printed September 1989
Reprinted July 1990

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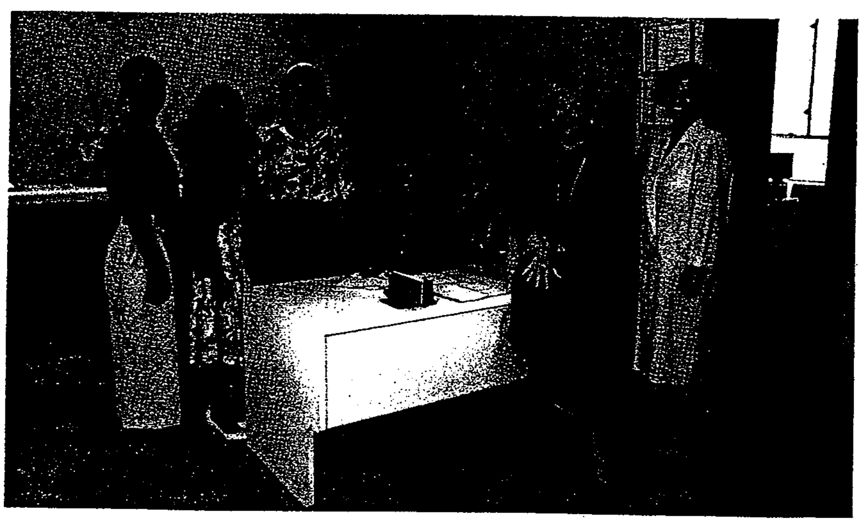
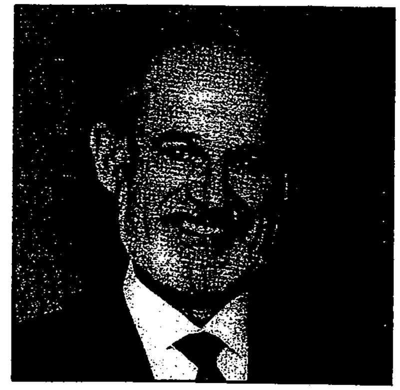


As contracted managers for this conference, Insight Planners played a key role in all the planning. Shown above are: Andrea Kovonovich, Grace Francisco, Robin Turnbull, Conference Manager Sherri Gage, Allyson Buchanan, President Lynne Gaetz and Lois McGrath.

HAR 278715

VNIS '89



A Message from the Conference Chairman

On behalf of the IEEE Vehicular Technology Society, the IEEE Toronto Section, the Ministry of Transportation of Ontario (MTO) and Transport Canada, I welcome you to Toronto and to VNIS '89 - the first conference devoted exclusively to vehicle navigation and information systems to be held in North America. Much effort has gone into bringing you a balanced and informative program which I hope you will find rewarding.

A major goal of the Conference is to encourage interaction between the diverse communities which have an interest in this area. These include the developers and potential users of the technology, the multiplicity of technical disciplines which are involved, and the various government, industrial and academic organizations responsible for funding, standards, research, and all the other considerations which must be addressed if application of this technology is to be wide spread. I think you will agree, we have gone a long way towards achieving this goal.

I wish to express my sincere appreciation to those individuals and organizations who have contributed to the success of VNIS '89. First and foremost, I would like to thank each member of the VNIS '89 Committee for their dedication and hard work over the past two years. In particular, thanks to Joe Tsai, Bob French and the Technical Program Committee for arranging an excellent program. Also, special thanks must go to Lamberto Gomes for organizing the exhibits, to Hugh Reekie for organizing publication of the Conference Record, and to Gene Dempsey for handling the local arrangements.

Rob Lockhart, Kim Deyarmond and Peryia Naidu of the MTO R&D Technical Publications Group deserve our appreciation for their excellent job of designing and laying out the Call for Papers and the Advance and Final Programs. The additional load carried by my secretary, Donna Bodegom, is also much appreciated. In producing this Conference Record, Hugh Reekie has had considerable assistance from Heather Morrison and Wendy Poirier at Nancy Poirier Typesetting; also the way in which Emil Holst and his production team at MOM Printing managed such things as last-minute papers is outstanding.

I also wish to thank Lynne Gaetz and Sherri Gage from Insight Planners for their assistance in handling the vast amount of administrative detail which running such a conference entails. And, since they are really what a conference is all about, I wish to thank the authors, panel members and the session moderators for their excellent contributions, and the exhibitors for bringing us interesting displays of the latest technology.

Without the promotional efforts of our Official VNIS Supporters (listed on the left), it is highly unlikely we would have so large a conference or such a wide ranging participation. Their assistance is much appreciated, as is that provided by the international coordinators.

Finally,on behalf of the IEEE Vehicular Technology Society and he IEEE Toronto Section, I would like to thank our sponsors, the Ministry of Transportation of Ontario and Transport Canada. Their involvement was essential in helping us launch and establish a new conference, which we hope is the first of a series of VNIS conferences to be held at various sites over the next decade. I hope you enjoy the conference, and that your stay in Toronto is a memorable one.

Rye Case, VNIS '89 General Chairman

VNIS '89 Committees

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Vice-Chairman William F. Johnson	Transport Canada

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Robert L. French (Vice-Chairman)	R.L. French & Associates, Fort Worth, TX
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William Law	Ministry of Transportation of Ontario

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H. Eugene Dempsey (Chairman)	Threshold Communications, Brampton, ON
Lamberto Gomes	Ministry of Culture & Communications of Ontario

Publicity and Publications Committee

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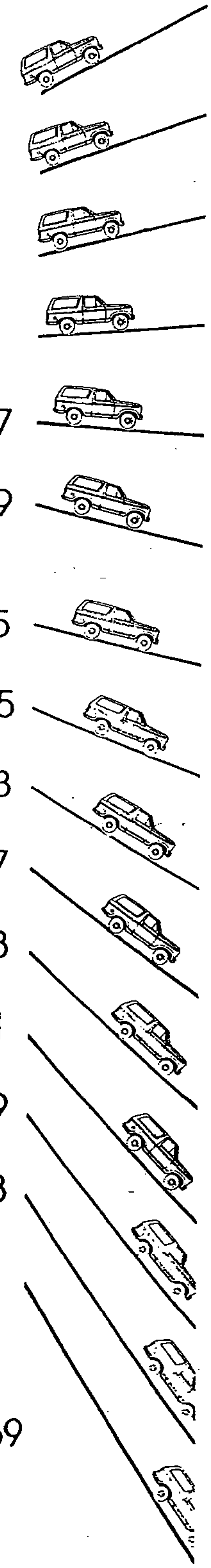
Glen Shortliffe	Deputy Minister

HAR 278717

Session index



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HAR 278718

VNIS '89 Steering Committee

The Steering Committee of VNIS '89 have held regular meetings for over a year. Shown above are:

Front row, Left to right - Lamberto Gomes, Chairman, Exhibits Committee, Rye Case, General Chairman, Bruno Di Stefano, Chairman, Finance and Education Committee and Hugh Reekie, Chairman, Publicity and Publications Committee.

Back row, left to right - Bill Law, Technical Program Committee, Joe Tsai, Chairman, Technical Program Committede, Gene Dempsey, Chairman, Local Arrangements Committee, Lynne Gaetz, Insight Planners Inc., Ataur Bacchus, Secretary, Bob French, Vice-Chairman, Technical Program Committee.

VNIS '89 Conference Committee Chairmen

Conference Chairman
E. Ryerson Case
Ministry of Transportation
1201 Wilson Ave
Downsview, ON. M3M 1J8
416-235-4676 FAX 416-235-4872

Conference Vice-Chairman
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Transport Canada
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Administration
Lynne Gaetz, Sherri Gage
Insight Planners Inc.,
133 Richmond St. W., Suite 502
Toronto, ON. M5H 2L3
416-868-6565 FAX 416-868-0936

VNIS 89 was very successful; so successful in fact that the 900 copies of the original print run have been distributed. I am pleased that the means has been found for this reprint of 400 copies, so that the *Conference Record* can reach a wider audience.

George McClure, President IEEE Vehicular Technology Society, May 1990

HAR 278719

EXHIBIT 17

DEGREES AWARDED

SEPTEMBER 20, 1989

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

Ronald James Wilson, B.A., M.C.P. (XI) SEP 25 '89
Markham, Illinois
~~Richmond Festival Marketplace~~
"Richmond's 6th Street Marketplace - Assessment of a Failed Festival Market"

MASTER OF SCIENCE

Without Specification of Field

Pedro Manuel Barbosa Ferraz de Abreu, Lic.(IV) FEB 27 '90
Lisboa, Portugal
Intelligent Graphic Interface - Capturing Rules of Human-Computer Interaction in a Knowledge Base

Peg Schafer, B.F.A. (IV) FEB 27 '90
Cambridge, Massachusetts
Try to Describe This Over the Phone: An Investigation of the Communication of Shape

John Andrew Watlington, S.B. (IV) FEB 27 '90
Memphis, Tennessee
Synthetic Movies

DOCTOR OF PHILOSOPHY

School of Architecture and Planning

Libero Andreotti, B.S., M.Arch. SEP 1 '89
Pisa, Italy
Thesis in the field of Architecture, Art, and Environmental Studies submitted to the Department of Architecture: Art and Politics in Fascist Italy: The Exhibition of the Fascist Revolution(1932)

Evangeline Kim Leaño Cuenco, B.A., M.A.
Baguio City, Philippines
Thesis in the field of Urban and Regional Planning submitted to the Department of Urban Studies and Planning: The Role of Mortgage Finance Vis-a-Vis Other Programmatic Interventions in Low-Income Housing in Developing Countries

James Raymond Davis, S.B. FEB 27 '90
Cambridge, Massachusetts
Thesis in field of Media Arts and Sciences submitted to the Department of Architecture: Back Seat Driver: Voice Assisted Automobile Navigation

Stephen McTee Ervin, M.L.A. JUL 25 '89
Saugus, Massachusetts
Thesis in the field of Design Theory and Methods submitted to the Department of Urban Studies and Planning: The Structure and Function of Diagrams in Environmental Design: A Computational Inquiry

Scott T. McCreary, B.A., M.L.A. JUL 26 '89
Berkeley, California
Thesis in the field of Urban and Regional Planning submitted to the Department of Urban Studies and Planning: Resolving Science-Intensive Public Policy Disputes: Lessons from the New York Bight Initiative

Leticia Rivera-Torres, B.A., M.A. SEP 27 '89
Boston, Massachusetts
Thesis in the field of Urban and Regional Studies submitted to the Department of Urban Studies and Planning: Tax Exemption and Industrial Development in Puerto Rico

DATE RECEIVED [illegible]

T[illegible] in the Marketing of Office Buildings"

EXHIBIT 18

FOR MIT USE ONLY

RECEIVED DEC 2 1 1989

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 MASSACHUSETTS AVENUE
CAMBRIDGE, MASSACHUSETTS 02139

E23-230 3-6787

COMMITTEE ON THE USE OF HUMANS AS EXPERIMENTAL SUBJECTS

12/13/89

ANNUAL REVIEW QUESTIONNAIRE

TO: Christopher Schmandt
E15-327

APPLICATION NO.: 1881

FROM: H. W. Jones, Jr., Chairman

DATE OF LAST APPROVAL: 01/20/1989

TITLE: Back Seat Driver

The approval of your project by the Committee on the Use of Humans as Experimental Subjects will expire one year after the date of last approval unless otherwise noted. Before extending its approval for an additional year, the Committee needs to know whether there have been any changes in your protocol. Would you please answer the questions below, explain any changes, and return the signed form to room E23-230. If your project has terminated, please let us know. If we fail to hear from you within the next 45 days, the COUHES approval for your protocol will be terminated automatically. Thank you.

	YES	NO	NOT APPLICABLE
1. Are you requesting renewal of COUHES approval for this project?	✓		
2. Has there been any change in:			
a) method of obtaining subjects?		✓	
b) experimental or interview procedure?		✓	
c) amount of blood drawn?			✓
d) amount of radiation exposure?			✓
e) experimental equipment?			✓
f) names of responsible investigators?			✓
g) other aspects of study which affect human subjects?			✓
3. Have you discovered any unforeseen discomforts or risks to subjects?		✓	
4. Does your study require the approval of any committee (e.g. Biohazards, Committee on Radiation Exposure, Hospital review board, Privacy Committee, etc.)?		✓	

5. Have any results of this study been published? If so, please provide bibliographic information (PLEASE SEND REPRINTS). yes- attached.

6. How many subjects have been used since the last approval? 14
Since the start of this project? 14

HIGHLY CONFIDENTIAL

OK
HJ

7. Please attach a copy of the informed consent document you are currently using (if a written consent form was not required for your protocol, please indicate).

PLEASE EXPLAIN ANY AFFIRMATIVE ANSWERS TO QUESTIONS 3-5 ON THE REVERSE SIDE.

Signature: Chr Smt

Date: 19 Dec 89

MIT 06762

Consent to be Experimental Subject with the Back Seat Driver.

We are required by regulations to obtain documentation of your informed consent in this experiment. Please read it carefully.

By my signature below, I understand that:

1) I will be asked to drive our car to various destinations in the Boston area selected by the experimenters. While driving, I will hear synthetic speech instructing me where to drive. At all times, at least one experimenter will be in the car with me, but this person will not answer questions while the experiment is in progress, unless my safety requires it.

2) Discomforts and risks: I will drive in traffic. I understand that driving in Boston is a stressful, and sometimes hazardous activity. My first concern in driving will be my safety.

3) There is no benefit to me in participating.

4) I will not participate in this experiment if I do not feel comfortable driving, because of weather, traffic, or any other reason.

5) The investigators will answer any questions I have about the procedure.

6) Withdrawal: I may stop the experiment at any time by stopping the car in a safe place.

7) I do not waive any rights by signing this form.

8) In the unlikely event of physical injury resulting from participation in this research, I understand that medical treatment will be available from the M.I.T. Medical Department, including first aid, emergency treatment and follow up care as needed, and that my insurance carrier may be billed for the cost of such treatment. However, no compensation can be provided for medical care apart from the foregoing. I further understand that making such medical treatment available, or providing it, does not imply that such injury is the Investigator's fault. I also understand that by my participation in this study I am not waiving any of my legal rights.

9) If I feel I have been treated unfairly as a subject I may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, MIT 253-6787

10) I hold a valid drivers license.

Signed________________________________

Print Name____________________________ Date __________________

EXHIBIT 19

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 MASSACHUSETTS AVENUE
CAMBRIDGE, MASSACHUSETTS 02139

E23-389 3-6787
COMMITTEE ON THE USE OF HUMANS AS EXPERIMENTAL SUBJECTS

COMMITTEE APPROVAL

DATE: 01/20/89

TO: Christopher Schmandt
E15-327

FROM: H. Walter Jones, Jr., M.D.
Chairman

APPLICATION NO.: 1881

TITLE: Back Seat Driver

RENEWAL DATE: 01/20/1989

Your application has been approved by the Committee on the Use of Humans as Experimental Subjects at its meeting on 01/19/89. This approval is valid until one year from the above renewal date, at which time your entire application will be due for annual review.

It is expected that you will notify the Committee of any further changes in your protocol, and also inform the Committee when your project is terminated. The COUHES number assigned to your project is 1881. In the future, please note this number on all correspondence referring to this project.

cc: T. Duff, OSP

1881 X

E15-327
22 Dec. 1988

Dear Dr. Jones,

This is further information with regards to your letter of 19 Dec. on our "Back Seat Driver" project.

The vehicle is MIT owned. As such, it and its occupants are covered by the blanket MIT vehicle policy. The Media Lab currently owns two other vehicles, both of which are used to convey students between E15 and off campus research facilities, on a daily basis. I can, of course, have Tom Henneberry confirm this if you wish.

While testing the Back Seat Driver, the car will never be driven without a research team member along, for several reasons. Most important, of course, is that the whole point of doing road trials is to observe actually using the system. Secondly, any audio or video recording will be done by the observer in the car. Thirdly, the research team member will be required to operate the computer equipment and cellular telephones in the car.

Since the driver is never alone, and is in fact accompanied by experienced local drivers with a thorough map database available, there is no fear of getting lost. We will be chosing the routes for the road trials, and would of course avoid any unsafe neighborhoods! In fact most of the driving will be in Cambridge, within a few miles of MIT.

We have no plans to drive during bad weather or unsafe road conditions; besides safety, this would result in non-uniform test data as subjects would be strained by the environmental factors. We may do some night driving, but this would be in the early evening, hardly in the middle of the night. And as for breakdowns, we have just purchased a brand new car so our vehicle is in excellent condition.

Presumably most of your concerns were based on the assumption that the driver would be alone, and I hope I have clarified that. I will ask Jim to submit a copy of the detailed proposal to you, and to verify insurance coverage with Tom Henneberry.

Please feel free to contact either of us for more information or proceedural suggestions.

Sincerely,

Chris Schmandt

Chris Schmandt
Director, Speech Research Group

EXHIBIT 20

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, **Plaintiff,** **v.** **HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED,** **Defendant.**	**Case No: 05-10990 DPW** **Hon. Douglas P. Woodlock**

MIT'S AMENDED RESPONSE TO HARMAN'S FIRST SET OF INTERROGATORIES (AMENDING RESPONSES TO INTERROGATORY NOS. 6-7)

Pursuant to Rules 26 and 33 of the Federal Rules of Civil Procedure, Plaintiff, Massachusetts Institute of Technology ("MIT") submits the following responses and objections to Harman International Industries, Incorporated's ("Harman's") First Set of Interrogatories (Nos. 1-7) [counted with subparts as Nos. 1-29] (the "Interrogatories"):

GENERAL OBJECTIONS

The following general statements and objections are incorporated into each of MIT's responses, as set forth there in full, even if not repeated therein:

1. MIT objects to the Interrogatories to the extent they refer to an Appendix A to Harman's First Set of Document Requests to MIT, which does not exist.

2. MIT objects to Harman's method of counting, but under Harman's counting method, Harman has served twenty-nine (29) interrogatories, and thus has exceeded the twenty-five (25) permitted by Rule 33 of the Federal Rules of Civil Procedure. Upon mutual agreement of

information provided regardless of whether such information is newly discovered or currently in existence. MIT may, in the future, obtain or locate additional information responsive to these Interrogatories. Further, a complete response to certain Interrogatories depends in part upon information to be adduced from Harman or third parties during discovery, which is in its early stages. MIT, therefore, reserves its right, at any time, to revise, amend, correct, supplement, modify, or clarify its responses, on a timely basis, in accordance with Federal Rules of Civil Procedure 26 and 33.

SPECIFIC OBJECTIONS AND RESPONSES

INTERROGATORY NO. 6

For each asserted claim of the Patent-In-Suit, state when a prototype that embodied each alleged invention of the patents in suit was first made and when and to whom such prototype was first disclosed; explain in detail the circumstances surrounding the prototype (including without limitation its making and disclosure); and identify all persons with knowledge of these events.

RESPONSE TO INTERROGATORY NO. 6 (ONCE AMENDED)

MIT objects to this interrogatory on the grounds that it is premature, because the response is dependent on contentions regarding claim construction, which both by agreement and by order of the Court, are not yet due in this matter. MIT further objects to this Interrogatory as premature to the extent it purports to request MIT to construe language of the written description of the '685 patent synonymously with language appearing in the claims of the '685 patent. MIT further objects to this interrogatory, because MIT has not yet completed its factual and legal analysis with regard to infringement and claim construction, and thus contention interrogatories regarding the interpretation of each claim are premature at this stage of the litigation. MIT further objects to this interrogatory because it seeks information protected by the attorney-client

privilege, work product doctrine, and/or other applicable privileges. MIT further objects to this interrogatory on the grounds that it is vague and ambiguous. Specifically, it fails to define the terms "prototype" and "alleged invention." MIT further objects to this interrogatory, because, when all subparts are counted according to Rule 33 of the Federal Rules of Civil Procedure, Harman has exceeded its limit of 25 interrogatories.

Subject to, and without waiving, the foregoing general and specific objections, MIT states that, to the best of its knowledge, there were at least three test units of the "Back Seat Driver" system. Initially, the inventors created a first test unit that required a person riding in the back seat of an automobile to input data regarding navigation of the automobile. The system utilized a remotely-stationed Symbolics-Lisp® brand computer. The system involved transferring data to and from the automobile over two lines of a cellular telecommunications system: one line for speech data and one line for other data. The speech generator in the first test unit was implemented using a Dectalk® brand speech synthesizer.

In a second test unit of the system, which was created prior to the time that Dr. Davis was awarded his Ph.D., the main computing apparatus was also a remotely-stationed Symbolics-Lisp® brand computer. This test unit included a location system that tracked the position of the automobile using the location system's own map database. The location system was supplied by Nippon Electronics Company ("NEC"). The speech generator in the second system was also implemented using a Dectalk® brand speech synthesizer, and, similar to the first test unit, the second system utilized two lines of a cellular telecommunications system to transfer data.

A third test unit of the system was created after MIT awarded Dr. Davis his Ph.D. in September 1989 and prior to the filing of U.S. Patent Application No. 565,274 on August 9,

1990. The third system included a Sun® brand Sparcstation® computer mounted in the trunk of an automobile. The third system also used the NEC location equipment.

All three test units were created for experimentation, research and development purposes in conjunction with research sponsored by NEC. The persons with information regarding the development of the device and any associated disclosure are the inventors, Dr. Davis and Prof. Schmandt.

At this time, MIT is unable to determine whether each or any of these test units embody one or more of the asserted claims in this action, because the Court has not yet construed the claims.

INTERROGATORY NO. 7

Identify each "working prototype of the Back Seat Driver" (*see, e.g.,* col. 3, lns. 4-5), including without limitation the date(s) upon which each such prototype was created , "implemented" (*see, e.g.,* col. 3, In. 5), demonstrated, displayed, shown, tested, and/or reduced to practice and each person involved in any such act, and describe how the "map database for the Back Seat Driver in [each] working prototype" (*see, e.g.,* col. 4, Ins. 13-15) represented "physical connectivity" and "legal connectivity" as those terms are used in the Patent-In-Suit (*see, e.g.,* col. 4, In. 61 - col. 5, In. 14).

RESPONSE TO INTERROGATORY NO. 7 (ONCE AMENDED)

MIT objects to this interrogatory on the grounds that it is premature, because the response is dependent on contentions regarding claim construction, which both by agreement and by order of the Court, are not yet due in this matter. MIT further objects to this Interrogatory as premature to the extent it purports to request MIT to construe language of the written description

of the '685 patent synonymously with language appearing in the claims of the '685 patent. MIT further objects to this interrogatory, because MIT has not yet completed its factual and legal analysis with regard to infringement and claim construction, and thus contention interrogatories regarding the interpretation of each claim are premature at this stage of the litigation. MIT further objects to this interrogatory because it seeks information protected by the attorney-client privilege, work product doctrine, and/or other applicable privileges. MIT further objects to this interrogatory on the grounds that it is vague and ambiguous. Specifically, it refers to terms from the specification and claims that have not yet been construed by the Court. MIT further objects to this interrogatory, because, when all subparts are counted according to Rule 33 of the Federal Rules of Civil Procedure, Harman has exceeded its limit of 25 interrogatories.

Subject to, and without waiving, the foregoing general and specific objections, MIT states that, to the best of its knowledge, there were at least three test units of the "Back Seat Driver" system. Initially, the inventors created a first test unit that required a person riding in the back seat of an automobile to input data regarding navigation of the automobile. The system utilized a remotely-stationed Symbolics-Lisp® brand computer. The system involved transferring data to and from the automobile over two lines of a cellular telecommunications system: one line for speech data and one line for other data. The speech generator in the first test unit was implemented using a Dectalk® brand speech synthesizer.

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All three test units were created for experimentation, research and development purposes in conjunction with research sponsored by NEC. The persons with information regarding the development of the device and any associated disclosure are the inventors, Dr. Davis and Prof. Schmandt.

At this time, MIT is unable to determine whether each or any of these test units embody one or more of the asserted claims in this action, because the Court has not yet construed the claims.

Dated: January 9, 2006

Respectfully submitted,

Massachusetts Institute of Technology,

By its Attorneys,

Kimberly A. Mottley

Steven M. Bauer (BBO# 542531)
David J. Cerveny (BBO# 638307)
Kimberly A. Mottley (BBO# 651190)
PROSKAUER ROSE LLP
One International Place
Boston, Massachusetts 02110-2600
Phone: 617-526-9600
Fax: 617-526-9899

CERTIFICATION

I, the undersigned, have reviewed MIT's Amended Responses to Harman's First Set of Interrogatories (Nos. 6-7). The responses set forth herein, subject to inadvertent or undiscovered errors or omissions, are based on and therefore necessarily limited by the records and information still in existence, presently recollected, thus far discovered in the course of preparation of the responses, and currently available to MIT. Consequently, MIT reserves the right to make any changes in or additions to any of these responses if it appears at any time that errors or omissions have been made therein or that more accurate or complete information has become available. Subject to the limitations set forth herein, said responses are true to the best of my present knowledge, information and belief.

I hereby certify under penalty of perjury that the foregoing is true and correct.

Executed on this 10th day of January, 2006.

John H. Turner Jr

John H. Turner, Jr.
Associate Director, Technology Licensing Office
On behalf of Massachusetts Institute of Technology

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on January 9, 2006, I caused a true and correct copy of the foregoing document to be served on the following counsel of record via email:

Robert J. Muldoon, Jr.
SHERIN AND LODGEN, LLP
101 Federal Street
Boston, MA 02110

William A. Streff Jr., P.C.
Michelle A. H. Francis
Jamal M. Edwards
KIRKLAND & ELLIS LLP
200 East Randolph Drive
Chicago, IL 60601
(312) 861-2000 (phone)
(312) 861-2200 (fax)

By: Kimberly A. Mottley
Kimberly A. Mottley

EXHIBIT 21

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No: 05-10990 DPW

REBUTTAL EXPERT REPORT OF M. ELIZABETH CANNON, PH.D.

I. Streeter

114. The French Report asserts that claims 1, 2, 7-9, 11-13, 19, 21, 23, 24, 27-29, 32, 34, 35, 36, 40-46, 48, 49, 54, and 56 are invalidated by the *Streeter* reference, either alone or in combination with other prior art.

115. The French Report refers to an article co-authored by Lynn Streeter, Diane Vitello, and Susan Wonsiewicz entitled *How to Tell People Where to Go: Comparing Navigational Aids* ("*Streeter*") (HAR000192-HAR000206).

116. Dr. Streeter's report contains a section discussing *Streeter*. I believe that *Streeter* does not invalidate the claims of the '685 patent because the claims of the '685 patent are not taught or suggested by *Streeter*. Moreover, the French Report has not shown by clear and convincing evidence that the claims of the '685 patent are invalid over *Streeter*. I do not intend my testimony at trial to be redundant, but if asked, am prepared to discuss *Streeter*, along the lines of Paragraphs 44-46 and 47-57 of Dr. Streeter's Report, attached hereto as Exhibit H and incorporated by reference.

J. Field Trials/Public Use

117. Harman has alleged that all of the asserted claims of the '685 are unenforceable because field trials conducted by Davis and Schmandt from April 1989 through August 1989 were not cited to the U.S. Patent and Trademark Office during prosecution of the '685 patent.

118. I understand that the field trials were conducted using MIT undergraduate students who drove an automobile equipped with a test prototype of the Back Seat Driver system. MIT1101; MIT06763; MIT06765. The field trials consisted of a driver driving an

automobile and a researcher, also in the car, observing the conduct and reactions of the driver. MIT06763; MIT06765. During the field trials, computing equipment was at the Media Lab at MIT. Schmandt Dep., p. 161, ll. 3-23; MIT1101. From the perspective of the driver, the experiment involved: (a) allowing a researcher to enter a destination via a keypad of a first cellular telephone, (b) awaiting an instruction to begin driving from the speaker of a second cellular telephone, (c), in response to receiving an instruction to being and a first driving instruction, maneuvering the vehicle, and (d) following subsequent driving instructions. MIT06765. The driver never had access to or otherwise observed the operation of at least the following components of the Back Seat Driver system as claimed in the ’685 patent: (a) the computing apparatus, (b) the map database, (c) the position sensing apparatus, (d) the location system, (e) the route-finder, or (f) the discourse generator. See MIT06765.

119. The researcher in the vehicle observed the output of the second cellular telephone and the driver’s reaction to that output. MIT06763; MIT06765. The researcher made note of the driver’s reaction and considered ways to improve the components of the Back Seat Driver system as a result. MIT06763; MIT06765. After a particular field trial ended, the researcher was able to improve the operation of the system by making changes to any of the components of the Back Seat Driver system.

120. Because the driver did not have access to at least 6 components of the Back Seat Driver system, as claimed in claim 1 of the ’685 patent, there was no use by the driver of the claimed invention; instead, the driver reacted to the output of the claimed invention. Both the output and the back-end algorithms were evolving in response to the field trials. Because there was no use of the invention by the driver, axiomatically, the field trials did not amount to public

use of the claimed invention. For at least this reason, the field trials were not material to the patentability of the claims of the ’685 patent.[2]

K. Harris and Calgary AVL System

121. Throughout the French Report reference is made to Harris, *Digital Map Dependent Functions of Automatic Vehicle Location Systems* (“Harris”) (MIT01092-MIT01100) in support of the invalidity of various claims or limitations thereof. I am familiar with this research prototype and the work that had been done at the University of Calgary in Automatic Vehicle Location Systems both before and after this paper was authored. In addition, I worked with the authors of this paper Clyde Harris, Laurie Klesh, Edward Krakiwsky, Hassan Karimi, and Ness Lee. The French Report uses Harris to support the allegation that the claims of the ’685 patent are invalid. See French Report pp. 8, 14, 15, 18, 22, 24, 26, 28, 30, 57, and Exhibit L. In view of Harris, it is my opinion that this research prototype does not anticipate or render obvious any of the claims of the ’685 patent at least because the system described in Harris did not contemplate speech generation or discourse generation. The system described by Harris lacked the sophistication to provide verbal instructions. Moreover, the “Route Guidance” text and context of Harris suggests that the functionality described had not been implemented. MIT01097. The type of instructions displayed or presented aurally to the driver were considered but not completed.

[2] In the event that the Court deems the driver’s exposure to the outputs of the Back Seat Driver system to be use, such use did not occur publicly, at least because the driver was not exposed the computing apparatus as it operated at the Media Lab during the field trials. Moreover, an observer viewing the driver maneuvering the automobile could not know that the car was being driven by a driver who was receiving real-time spoken instructions from the Back Seat Driver system. Finally, in the university setting, there is an ethical obligation on students not to disclose the work of another, and therefore, work disclosed to students in labs is not considered a “public” use.

The foregoing Rebuttal Expert Report of M. Elizabeth Cannon, Ph.D, in connection with the patent infringement action between MIT and Harman, is submitted as of the date below, having been prepared and reviewed by the undersigned.

Dated: August _22, 2006

M. Elizabeth Cannon

____

M. Elizabeth Cannon, Ph.D.

EXHIBIT 22

UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	)	Civil Action No. 05-10990-DPW

Expert Report of Lawrence M. Sung

Supreme Court, particularly on the issue of patent unenforceability due to inequitable conduct. I have also generally considered the documents included in Exhibit B. In addition, I have considered the relevant sections of Title 35 of the United States Code, Title 37 of the Code of Federal Regulations, and the Manual of Patent Examining Procedure ("MPEP").

I understand that discovery is ongoing in this case. I therefore reserve the right to adjust or supplement my opinions after I have had the opportunity to review deposition testimony or in light of additional documents that may be brought to my attention. I also reserve the right to adjust or supplement my analysis in light of any critique of my report or alternative opinions advanced by or on behalf of the plaintiff. To date, I have not prepared any exhibits summarizing my opinions or illustrating points made in this report, but I expect to do so for use at trial in accordance with the Court's orders. Finally, I reserve the right to testify on other legal issues, should the occasion present itself, if another patent law expert is allowed to do so or if the Court will otherwise permit me to do so.

(b) Qualifications

In 1985, I earned a Bachelor of Arts degree in Biology from the University of Pennsylvania (Philadelphia, PA). In 1990, I received a Doctor of Philosophy degree in Microbiology from the United States Department of Defense, Uniformed Services University of the Health Sciences (Bethesda, MD). In 1993, I obtained a Juris Doctor degree from The American University, Washington College of Law (Washington, DC). After law school, I served as a judicial clerk to (now Senior) Circuit Judge Raymond C. Clevenger, III, of the United States Court of Appeals for the Federal Circuit (Washington, DC).

My private law practice concentrating on intellectual property law spans over thirteen years. I have been registered patent attorney since 1994 and have prepared and/or prosecuted over 60 patent applications. I continue to work in all phases of patent prosecution

today, including the preparation and filing of patent applications with the PTO, the submission of information disclosure statements, and the transaction of business with patent examiners.

In addition to my private law practice, I presently hold the appointment of Law School Professor and Director of the Intellectual Property Law Program at the University of Maryland School of Law (Baltimore, MD). I have been a member of various law school faculties, as an adjunct professor from 1996-1999, as an assistant professor of law from 1999-2003, and as a full professor since 2003. Besides the University of Maryland School of Law, I have also taught at the Lewis & Clark Law School (Portland, OR), the George Washington University Law School (Washington, DC), The American University, Washington College of Law, and the Seattle University Law School (Seattle, WA). The courses I have taught include Intellectual Property Law Survey, Patent Law & Policy, Licensing & Technology Transfer Policy, Biotechnology Law, Trademark Law, and Civil Procedure.

I have published many articles on relating to intellectual property law concerns, and I authored two books, "The Patent Law Handbook" and "Patent Infringement Remedies," both of which include sections pertaining to the topic of patent unenforceability due to inequitable conduct. A full listing of all of my publications in the last ten years is included in my curriculum vita is attached as Exhibit A.

I am active in several professional organizations and provide regular training sessions for other intellectual property law attorneys. For example, for the past five years, I have been on the conference faculty of the American Intellectual Property Law Association ("AIPLA") program "Practical Patent Prosecution Training for New Lawyers," and the American Law Institute – American Bar Association ("ALI-ABA") program "Trial of a Patent Case."

I have been retained as an expert since 2001 in about eight matters, about four of which were as an expert opining on inequitable conduct issues regarding the duty of candor, materiality, and intent. In addition, I have been involved as an attorney in numerous federal court cases where inequitable conduct was an alleged defense or counterclaim, including over a dozen such cases before the Federal Circuit. For example, I have been involved with the appeals recently before the Federal Circuit in *Digital Control, Inc. v. Charles Mach. Works*, 437 F.3d 1309 (Fed. Cir. 2006) and *Bruno Independent Living Aids, Inc. v. Acorn Mobility Servs., Ltd.*, 394 F.3d 1348 (Fed. Cir. 2005).

2. General Legal Considerations

(a) Patent Office Practice

As the United States Constitution mandates, the patent system in the United States is designed to advance the progress of the useful arts by encouraging invention. The process does this by encouraging individuals to invent something new and useful. The incentive for the inventor to go ahead and expend their time, money, and ingenuity to create an invention is that if the inventor then discloses how to make and use that invention, the inventor will be issued a patent that is effective for a term of years. A valid and enforceable patent allows the inventor to exclude others from enjoying the invention without the patent owner's permission. In certain instances, this would allow the patent owner to wield monopoly power over the sales and use of the invention. However, in order to gain these rights, the inventor must comply with all of the rules and regulations of the PTO pertaining to the application for a patent.

The patent application is comprised of several documents, which may be drafted by the applicant, but more likely by the applicants' patent attorney (as used in my report the term "applicant" refers to either the actual applicant(s) or their patent attorney). Certain parts of the patent application are incorporated into the document that is called a "patent." Included among

(ii) State of the Prior Art

In addition to the above, various other prior art references that the applicants should have disclosed to the PTO belied the applicants' statement that "very little has been published about [CARIN]" including the 1987 Thoone Article [Davis Exhibit No. 85]; the 1987 Thoone Article [MIT 51-60]; U.S. Patent No. 4,758,959 (the Thoone '959 Patent); GDF [MIT 02605-03137]; and "GDF, A Proposed Standard ..." presented at the Sept. 1989 conference that Dr. Davis presented Back Seat Driver [HAR 102488-494]. These documents all involve research that the applicants were clearly aware of (as evidenced by their reliance and citation to other contemporaneous Thoone papers). Furthermore, it is reasonable to infer that Dr. Davis as a participant and presenter at the VNIS Conference received a copy of the Conference Proceedings and was aware of the articles contained in those Proceedings, particularly those dealing directly with the subject matter of the Back Seat Driver. *See* [HAR 278710-9253].

(c) Other Non-Compliance with the Duty of Candor

(i) Field Trials

In addition to the foregoing, I have concluded that the patent applicants failed to comply generally with the duty of candor they owe to the PTO. For example, MPEP § 2004 ¶ 11, states that:

> It may be desirable to submit information about prior uses and sales even if it appears that they may have been experimental, not involve the specifically claimed invention, or not encompass a completed invention.

However, from the prosecution history of the '685 patent, it is clear this was not done. For instance, in addition to the public use of Direction Assistance, the Davis thesis provides an implicit admission that the Back Seat Driver was in public use before the critical date of August 9, 1989. Indeed, the Davis thesis reveals that the "Back Seat Driver is an actual

working prototype." [MIT 5754]; *see* Davis Dep. at p. 85:1-91:15; Schmandt Dep. at p. 184:1-185:8. To the extent this is an accurate statement, then the signing of this document on August 4, 1989, indicates that the patented invention was involved in an invalidating public use under 35 U.S.C. § 102(b). The statement in the Davis thesis appears corroborated by similar statements in the Davis article ("Running in prototype form since April 1989") [MIT 938]; ("In the course of field trials ...") [MIT 1101]; ("The Back Seat Driver is already working in prototype form") [MIT 4078]; ("The Back Seat Driver is a research prototype ...") [MIT 933]. In any event, the applicants' focus on the public availability of the Davis thesis after the August 4, 1989, date of the signature on the document is irrelevant to whether the patented invention was in public use before the critical date. The materiality of these uses is not in doubt. MIT has admitted that the subject matters of claims 1-4, 7-9, 19, 21, 23-25, 32-37, 40-41, 53, 55, and 57-58 were embodied in the field trials before June 1989, and the subject matters of claims 1-4, 7-9, 15, 19, 20-21, 23-37, 40-49, 51-55, 57, and 58 were embodied in field trials that occurred before August 4, 1989. *See generally* Schmandt 30(b)(6) Dep. at p. 18-80. MIT also admits that the subject matters of claims 1-4, 7-9, 11, 21, 23-37, 40-49, 51-55, 57, and 58 were reduced to practice at least as early as June 1989, meaning that "field trials" that occurred after that date could not have been for purposes of experimentation of that subject matter. *See* Davis Dep. at p. 85:1-91:15; *See generally* Schmandt 30(b)(6) Dep. at p. 35-79. Moreover, even if the field trials for some (or even all) of the claimed subject matters were for the purposes of experimentation, the applicants were still required to disclose any experimental public uses that occurred more than one year before the filing of the application under MPEP § 2004 ¶ 11. By failing to do so, the applicants failed to comply with the Rule 56 duty of disclosure.

The materiality of these public uses is further evidenced by the patent examiner's express concern over the actual publication date of the Davis thesis solely for purposes of a 35 U.S.C. § 102(e) rejection. [HAR 000119; HAR 000132]. It is clear that no further regard was taken on the statement regarding the use of a working prototype of the invention before the critical date. If it had been, the patent examiner could have properly rejected the patent claims under § 102(b) for a public use bar to patentability. As it was, because the field trials were not specifically and separately disclosed in the IDS, the existence of and the relevance of the field trials, like the Streeter article and the Direction Assistance papers and exhibit, was effectively "buried" within the articles incorporated by reference by the applicants. As such, aside from the possible implications for invalidity of the '685 patent claims, in my opinion the failure of the applicants to disclose these activities to the PTO constitutes inequitable conduct.

The evidence that the failure to disclose these public uses was intentional includes all of the evidence discussed above with respect to the other withheld information. In addition, the applicants were aware that there was an issue of whether they had publicly disclosed the invention more than one year before the filing date of the '685 patent. One of the documents produced by MIT in this case notes that the first public disclosure of the Back Seat Driver system occurred in June 1989. [MIT 1401]. Although the applicants disclosed the printed publication that mentions the earlier field trials, they chose not to separately make the examiner aware of those field trials, or to tell the examiner that the field trials embodied the subject matters recited in the majority of the claims being prosecuted. It is reasonable to infer that this was an intentional decision, and that the applicants chose to only disclose the Davis thesis as a printed publication, rather than a detailed explanation of the field trials and the subject matter embodied therein as a public use.

not provide the examiner with a copy of that article—even when specifically asked for one. Moreover, the applicants made the affirmative statement to the examiner that those documents not provided were not relevant. In so doing, the applicants effectively dissuaded the examiner from any further searching for those references. As such, the applicants' "burying" of material prior art and the failure to provide references under the guise that they were not relevant was a breach of the applicants' Rule 56 duty of candor.

Therefore, in view of the high degree of materiality for these breaches of the Rule 56 duty of candor coupled with evidence in this case of an intent to deceive the PTO, I would conclude, and it is my opinion that the applicants engaged in inequitable conduct before the PTO.

Dated this 18TH day of July 2006

Lawrence M. Sung

EXHIBIT 23

UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No. 05-10990-DPW

REBUTTAL EXPERT REPORT OF STEPHEN G. KUNIN

the patent examiner." *Allied Colloids, Inc. v. Am. Cyanamid Co.,* 64 F.3d 1570, 1578 (Fed. Cir. 1995). Intent to deceive "cannot be inferred solely from the fact that information was not disclosed; there must be a factual basis for a finding of deceptive intent." *Purdue Pharma L.P. v. Endo Pharms., Inc.,* 438 F.3d 1123, 1134 (Fed. Cir. 2006).

35. Moreover, "where the only evidence of intent is lack of a good faith explanation for the nondisclosure, [this] cannot constitute clear and convincing evidence sufficient to support a determination of culpable intent." *M. Eagles Tool Warehouse, Inc. v. Fisher Tooling Co.,* 439 F.3d 1335, 1341 (Fed. Cir. 2006). "When the absence of a good faith explanation is the only evidence of intent, however, that evidence alone does not constitute clear and convincing evidence warranting an inference of intent." *Id.* at 1341.

2. Initial Rebuttal of The Sung Expert Report.

a. Qualifications.

36. On pages 3 through 5 of Mr. Sung's Expert Report dated July 18, 2006 he sets forth his qualifications. However, I do not find that Mr. Sung has set forth his qualifications as a technical expert in the field of automobile navigation systems. Even under the definition provided by Harman's technical expert Mr. French, Mr. Sung is not a person of ordinary skill in the automobile navigation systems art, because Mr. Sung does not have "approximately five years of experience in research, systems architecture, design, and testing relating to vehicle navigation and route guidance systems [nor does he] possess[] a Bachelors Degree or higher in computer technology, physics, engineering, cartography, mathematics, or related technical fields." *See* Expert Report of Robert French at pages 3-4. While I understand that the thrust of Mr. Sung's report deals with whether the Inventors Davis and Schmandt or their attorney Mr. Sam Pasternack violated their duty of disclosure when prosecuting the '685 patent-in-suit, such a determination requires a materiality evaluation which must be made by a technical expert or at

least by a person of ordinary skill in the art. I have reviewed both the report of Robert French (Harman International Industries, Incorporated's technical expert) and the expert report of Mr. Sung, and find that all of the assertions made by Mr. Sung regarding the materiality of certain information are based upon his own evaluation, as opposed to reliance on Mr. French and his report. In my opinion, Mr. Sung is not technically qualified to render independent opinions on the materiality of the information he has relied upon in his determination that the '685 patent-in-suit should be unenforceable because of inequitable conduct having been committed.

37. Mr. Sung also indicates that he is an expert opining on inequitable conduct issues regarding intent. However, I question whether Mr. Sung should be permitted to testify as to the issue of intent, since it is my understanding that questions of intent are peculiarly within the province of the fact finder rather than being a permissible area of testimony for patent law experts. *See Molins PLC v. Textron, Inc.*, 48 F.3d 1172, 1181 (Fed. Cir. 1995).

b. Inequitable Conduct.

38. On pages 8-11 of his report, Mr. Sung discusses the law of inequitable conduct. What Mr. Sung does not say, however, is that a violation of the duty of disclosure requires that an individual having a duty of disclosure obligation be aware of the materiality of the prior art reference. Moreover, Mr. Sung does not indicate that proof of materiality requires that the information that was not disclosed is not cumulative. It is the accused infringer's burden to establish that the information is not cumulative to information already of record in the prosecution history. This is done by comparing the undisclosed information with all of the information already of record and determining that the undisclosed information "discloses a more complete combination of relevant features, even if those features are before the patent examiner in other references." *See Semiconductor Laboratory Co. v. Samsung Electronics Co.*,

to patentability. In my opinion neither the characterization of the CARIN system in the IDS nor the failure to disclose the CARIN system were inequitable conduct.

- Mr. Sung has not established by clear and convincing evidence that there was a public use either under 35 U.S.C. § 102(b), or 35 U.S.C. § 103(a) based upon 35 U.S.C. § 102(b), of the inventions covered by the claims of the '685 patent. In my opinion the failure to disclose the Back Driver Field Trials was not inequitable conduct.
- Mr. Sung has not established by clear and convincing evidence that Inventors Davis and Schmandt or Attorney Pasternack violated the duty of disclosure in failing to bring to Examiner Lall's attention the thesis bibliography references not cited in an IDS or to provide copies of publications that were listed in the IDS. In my opinion the failure to disclose the Davis thesis bibliography references and other articles incorporated by reference into the '685 patent was not inequitable conduct.

VIII. RIGHT TO SUPPLEMENT OR AMEND

85. I reserve the right to supplement and/or amend the opinions expressed herein in response to positions taken by Harman or Harman's experts, to amplify what is stated above, where necessary, and especially in view of information not presently known to me or new information presented by Harman's experts prior to, or at trial, and to supplement this report should additional information be brought to my attention during the course of this proceeding.

Dated: August 22, 2006

Stephen G. Kunin

EXHIBIT 24

Excerpts from the:

February 8, 2006
Deposition of
Christopher Schmandt

VOLUME 1

PAGES 1 - 301

EXHIBITS D32 - D44

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF MASSACHUSETTS

No. 05-10990 DPW

- -

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiffs

vs.

HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED,

Defendants

- -

VIDEOTAPED DEPOSITION OF CHRISTOPHER M. SCHMANDT

Wednesday, February 8, 2006 9:38 a.m

Proskauer Rose LLP

One International Place, Boston, MA 02111

Reporter: Janet M. Konarski, RMR, CRR

LegaLink Boston

320 Congress Street, Boston, MA 02110

(617)542-0039

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ALSO PRESENT:
Robert P. Hart, Chief Intellectual Property
Counsel, Harman International
Jason Lachapelle, Videographer
* Not present at all times

I N D E X

WITNESS	DIRECT	CROSS	REDIRECT	RECROSS
CHRISTOPHER M. SCHMANDT				
By Mr. Leavell	6			

E X H I B I T S

Number	Description	Page
D32	U.S. Patent 5,177,685	19
D33	Document bearing MIT Bates No. 943 through 947	67
D34	Document bearing MIT Bates Numbers MIT 266 through 432	68
D35	Article Bates stamped 03846 through 3854	117
D36	Document Bates stamped 01674 through 01706	134
D37	Document Bates stamped MIT 1715 through MIT 1748	141
D38	Document Bates stamped MIT 1617 through 1628	143
D39	Document Bates stamped MIT 1370 through MIT 1385	144
D40	Document Bates stamped MIT 1957 through 1975	154

E X H I B I T S

Number	Description	Page
D34A	Document Bates stamped MIT 336 through 344	163
D34B	Document Bates stamped MIT 345 through 358	169
D41	Document Bates numbered MIT 4075 through 4079	181
D42	Copy of U.S. Patent No. 4,758,959	194
D43	Document Bates stamped Harman 1643 through Harman 1656	247
D44	Document Bates stamped HAR1476 through 1642	280

THE VIDEOGRAPHER: Here begins Videotape No. 1 in the deposition of Chris Schmandt in the matter of Massachusetts Institute of Technology v. Harman International Industries, Incorporated in the United States District Court for the District of Massachusetts, Case No. 05-10990DPW. Today's date is February 8, 2006. The time on the video monitor is 9:38 a.m.

The video operator today is Jason Lachapelle, a notary public, contracted by LegaLink Boston. This deposition is taking place at One International Place, Boston, Massachusetts, and was noticed by Kirkland & Ellis for the defense.

Counsel, please voice identify yourself and state whom you represent.

MR. BAUER: Steven Bauer from Proskauer Rose, representing MIT and the witness.

MS. MOTTLEY: Kimberley Mottley from Proskauer Rose, representing MIT and the witness.

MR. LEAVELL: Craig Leavell from Kirkland and Ellis, representing Harman.

MR. HART: Robert Hart representing Harman International.

THE VIDEOGRAPHER: The court reporter

today is Janet Konarski. Would the reporter please swear in the witness.

CHRISTOPHER M. SCHMANDT,

having been duly sworn, after presenting identification in the form of a driver's license, deposes and says as follows:

DIRECT EXAMINATION

BY MR. LEAVELL:

Q. Good morning, sir.

A. Good morning.

Q. We've introduced each other, but for the record, my name is Craig Leavell, and I'll be taking your deposition today. It's important that you understand each question that I ask of you. So, if there is any time that you don't understand a question or any portion of a question that I ask you, will you let me know, so that I can rephrase or try to fix the question?

A. I'll do my best.

Q. It's also important that you hear my questions. If there is a question I ask that you don't hear, will you let me know, so that I can repeat it?

A. Again, I'll do my best.

Q. If at any time today you realize that an

Q. What does it mean for the map database to have a minimum accuracy of 10 meters?

A. That means that where the map database says something is located on the surface of the earth that the actual location is within 10 meters of the said location.

Q. What was the map accuracy of the actual system built by MIT?

A. I don't recall. It's probably documented in Jim's thesis.

Q. Did the map database that was actually used on the Back Seat Driver built by MIT start out as a dime file?

A. If you want a -- I think in order to answer that question I would have to refer to the documents.

Q. What documents?

A. Jim Davis's thesis.

Q. Okay. Well, we'll get to that. What type of car was the Back Seat Driver installed in?

A. Acura Legend.

Q. Where was that -- was that car ever parked out in the open with the system in it, or was there an effort made to keep it more secure than that?

A. It was parked in an MIT garage, which had card access.

Q. But, the system was left in their overnight? It wasn't removed every time the car was parked?

A. There were several versions of the system. In one version of the system, the system, the computer portion of the system was in a machine room at the MIT Media Lab, and it never left that room.

Q. Right.

A. And the other portion -- the other version, the computer portion of the system was in the trunk of the car and was firmly attached by means of anti-vibration platform to the trunk of the car.

Q. When was the switch made from the computer being located in the Media Lab to being located in the trunk of the car?

A. I can't give you an exact date, but it was sometime after the time that Jim Davis graduated.

Q. When did he graduate?

A. He graduated in -- at the end of the summer. I don't know whether the date is August or September of 1989. At that point, we requested and received another year's funding from NEC, the primary

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF CHRISTOPHER M. SCHMANDT
February 8, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
Global	Global	Change "Trobough" to "Trobaugh"	Transcription error
Global	Global	Change "realtime" to "real time"	Transcription error
Global	Global	Change "dime" to "DIME"	Transcription error
10	15	Change "I was" to "They were"	Clarification
51	2	Change "media lab" to "Media Lab"	Transcription error
57	17	Change "you o know" to "you know"	Transcription error
68	20	Change "Stephen Marte" to "Stefan Marti"	Transcription error
69	8	Change "sense" to "since"	Transcription error
78	23	Change "invention" to "information"	Clarification
79	8	Change "invention" to "information"	Clarification
89	4-5	Change "committee on the use of humans in experimental subjects" to "Committee on the Use of Humans as Experimental Subjects"	Transcription error
96	3	Change "Rittbueler" to "Rittmueller"	Transcription error
128	24	Change "now" to "know"	Transcription error
130	8	Change "we're" to "were"	Transcription error
130	9	Change "we're" to "were"	Transcription error
131	21	Change "MS. MOTTLEY" to "MR. HART"	Transcription error
158	1	Change "tie-down" to "tied-down"	Transcription error
182	16	Change "tit" to "it"	Transcription error
186	13	Change "List" to "Lisp"	Transcription error
186	13	Change "Spark" to "Sparc"	Transcription error
202	15	Change "68,000" to "68000"	Transcription error
203	4-6	Change "Yes. 'The computing apparatus appears to be a pair of microprocessors, at least one of which is a Motorola 68,000.'" to "Yes. The computing apparatus appears to be 'a pair of microprocessors, at least one of which is a Motorola 68000.'"	Transcription error
205	8	Change "It's a drawing. So, one of" to "It's a drawing. BY MR. LEAVELL: Q. So, one of"	Transcription error
213	20	Change "their" to "the"	Transcription error
216	15	Change "lane be" to "lane may be"	Transcription error
234	5	Change "list" to "Lisp"	Transcription error
238	11	Change "an affeer of" to "anaphora"	Transcription error
251	6	Change "media library" to "Media Lab Library"	Transcription error

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF CHRISTOPHER M. SCHMANDT
February 8, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
259	16	Change "degenerative rates" to "degenerates"	Transcription error
278	17	Change "hardware man" to "Harman"	Transcription error
280	12-13	Change "Before Voice Assisted Automobile Navigation" to "Back Seat Driver: voice assisted automobile navigation"	Transcription error
285	10	Change "spark station" to "Sparc Station"	Transcription error
286	4	Change "tiger" to "TIGER"	Transcription error
287	9	Change "deertation" to "dissertation"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Christopher M. Schmandt